# SAE journal

JUNE 1957

IN THIS ISSUE . . .



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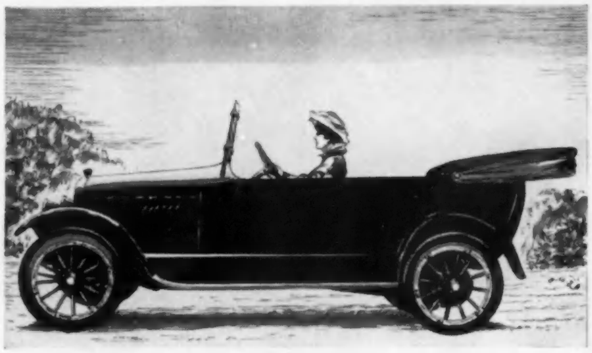
# When Compression Ratios were 3 to 1



Twelve cylinders or Six? Through an ingenious design, the 1917 V-12 Enger engine could be instantly changed into a 6-cylinder engine for "ordinary" driving. A cam shaft control on the steering column held open the exhaust valves on one bank of cylinders, closing a shutter that prevented fuel from entering combustion chambers and eliminating compression.

...any good oil ring would do!

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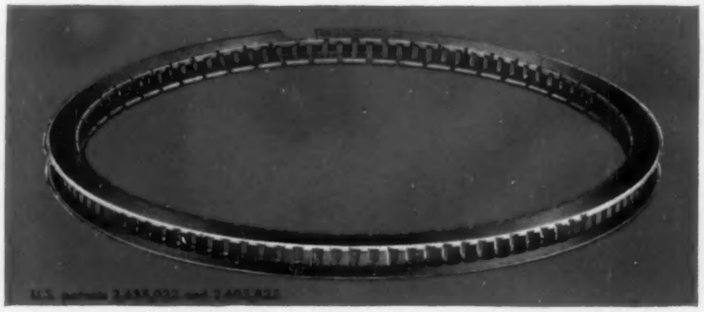
# TYPE "98" CHROME OIL RING

## to meet the exacting demands of modern high-compression engines

- **Specifically designed for today's high-compression engines.**
- **Universal application... bottomless and conventional grooves... all depths.**
- **Multiple tiny springs exert both side and radial pressure.**
- **Provides maximum oil drainage.**

**Best for new engines...**
**essential for worn engines**



# PERFECT CIRCLE

## PISTON RINGS

*Preferred by more people than any other brand*

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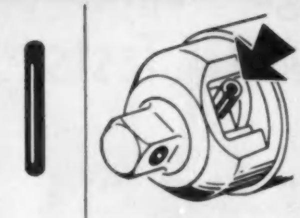
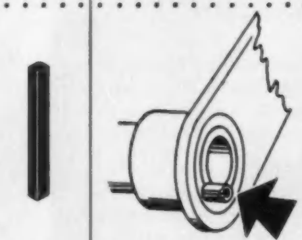
SAE JOURNAL, June, 1957, Vol. 65, No. 7. Published monthly except two issues in January by the Society of Automotive Engineers, Inc. Publication office, at 10 McGovern Ave., Lancaster, Pa. Editorial and advertising department at the headquarters of the Society, 485 Lexington Ave., New York 17, N. Y. $1 per number; $10 per year; foreign $12 per year; to members 50 cents per number, $5 per year. Entered as second class matter, September 15, 1948, at the Post Office at Lancaster Pa., under the act of August 24, 1912. Acceptance for mailing at special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph (d-2), Sec. 34.40, P. L. and R., of 1918. Additional entry at New York, N. Y.

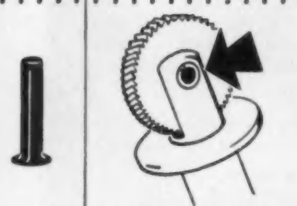
# Rollpin® replaces 12 different fasteners



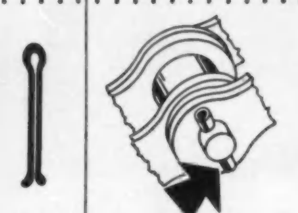
**REPLACING A GROOVED PIN . . .** in this application, Rollpin serves as a stop pin in a ratchet wrench adaptor. With its light weight and high shear strength, Rollpin functions perfectly . . . cuts assembly costs.



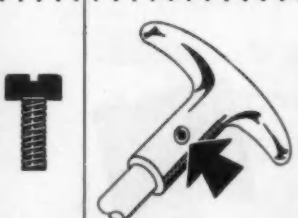
**REPLACING A KEY . . .** Rollpin demonstrates its ability to do away with precision tolerances, in this heating system damper arm. Faster, cheaper and more satisfactory than previous assemblies.



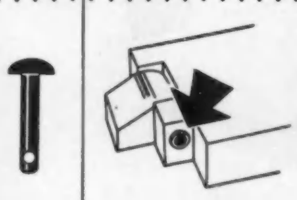
**REPLACING A RIVET SHAFT . . .** Rollpin serves as an axle for the sparkwheel of a cigarette lighter. No riveting or threading necessary . . . faster assembly. Note flush, clean fit.



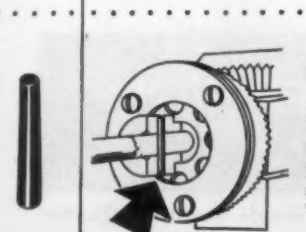
**REPLACING A COTTER PIN . . .** Rollpin assembly time is shorter, service life ten times longer. Vibration-proof flush fit. Easily removable.



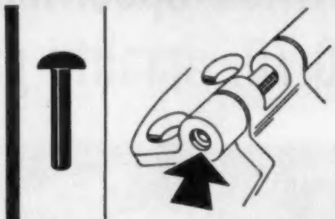
**REPLACING A SET SCREW . . .** to fasten automobile brake handle a short length Rollpin is self-retained in the hand grip but can easily be driven into over-drilled hole in shaft for simple handle removal.



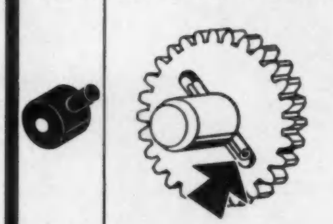
**REPLACING A CLEVIS PIN . . .** here Rollpin holds firmly in clevis, permits free action of moving member. Rollpin application shown is the plate of a home workshop tool.



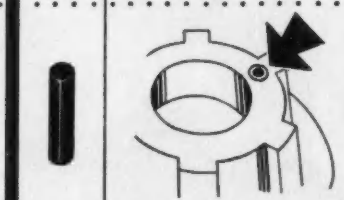
**REPLACING TAPER PINS . . .** in the assembly of precision differentials eliminated cost of taper pin reamers and the entire reaming operation. Rollpin costs less than a taper pin and installation is cheaper. They remove easily.



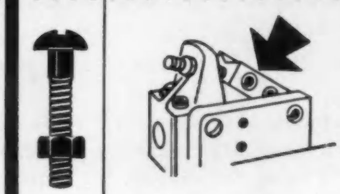
**REPLACING A HEADED PIN . . .** in this hinge pin application, Rollpin is simply and inexpensively driven in place, greatly reducing assembly costs. Constant spring tension holds Rollpin firmly in place . . . eliminates loosening of hinge due to wear.



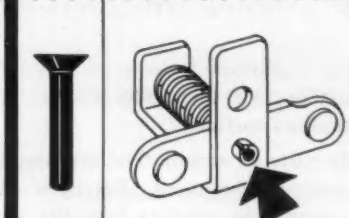
**REPLACING A HUB ON A GEAR . . .** Rollpin, self-retained in shaft, is simply snapped into molded slot to position sintered gear. This application, by an office equipment manufacturer, effects major savings in assembly. Rollpin's high shear strength is particularly valuable here.



**REPLACING A DOWEL PIN . . .** Rollpin is used here to prevent rotation of a thrust bearing. No reaming, no special locking. Easily removed. Lowest possible dowel pin cost.



**REPLACING A BOLT AND NUT . . .** Rollpins act as fasteners and pivots for the linkages in this electric welder. Rollpins may be used with a free fit in outer or inner members depending upon product design requirements.



**REPLACING A RIVET . . .** Rollpin serves as guide shaft for spring-loaded electrical interlock contacts. This electrical equipment manufacturer reports that rivet failure previously occurred at the clinched end under normal operating impact and vibration.

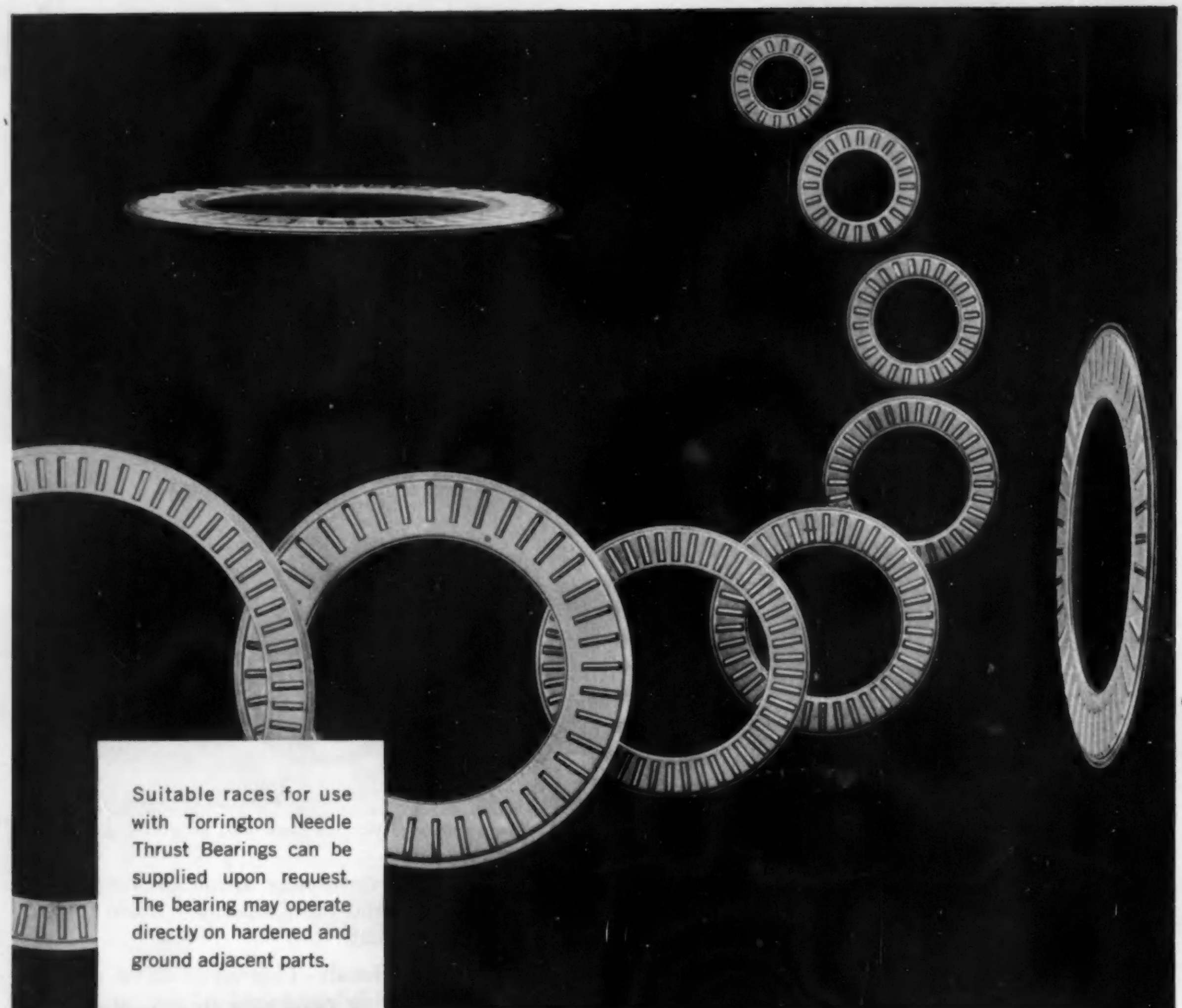
## WHERE CAN YOU USE THIS SIMPLE FASTENER?

**Rollpin is the slotted tubular steel pin with chamfered ends that is cutting production and maintenance costs in every class of industry.**

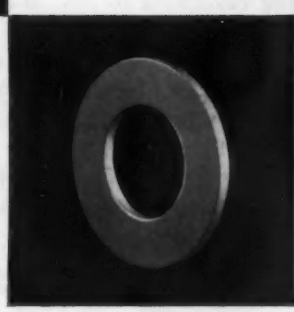
**Drives easily into standard holes, compressing as driven. Spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. Rollpin is readily removable and can be re-used in the same hole. Made in carbon steel, stainless steel and beryllium copper. Write for samples and information, ELASTIC STOP NUT CORPORATION OF AMERICA, 2330 Vauxhall Road, Dept. R47-675, Union, New Jersey.**

ROLLPIN TRADEMARK

ELASTIC STOP NUT CORPORATION OF AMERICA
2330 VAUXHALL ROAD, UNION, NEW JERSEY



Suitable races for use with Torrington Needle Thrust Bearings can be supplied upon request. The bearing may operate directly on hardened and ground adjacent parts.



# Torrington's new Needle Thrust Bearing grows in popularity...and range of sizes

Designers have been quick to take advantage of the compactness, high thrust capacity and low unit cost of Torrington's new Needle Thrust Bearing.

To meet the growing demand for this bearing in automatic transmissions, governors, steering gears, bevel gears, hydraulic pumps, torque converters and many other applications, tooling has been completed to produce bearings ranging from .500" ID to 3.000" ID.

Only .0781" thick, the Torrington Needle Thrust Bearing is thin as an ordinary thrust washer, yet brings all the advantages of anti-friction operation to applications where space is limited. Mating steel retainer halves are joined securely to form a self-contained unit that is easy to handle and install.

Plan today to evaluate the Torrington Needle Thrust Bearing. Services of our Engineering Department are available to help you. For full information, write for Bulletin No. 16, "Torrington Needle Thrust Bearings." *The Torrington Company*, Torrington, Conn.—and South Bend 21, Ind.

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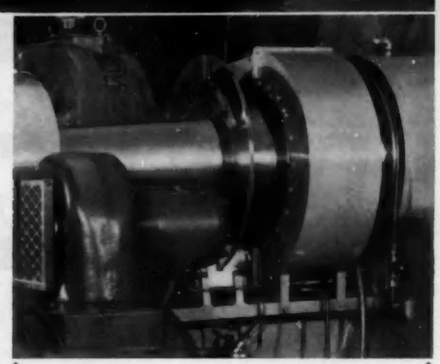
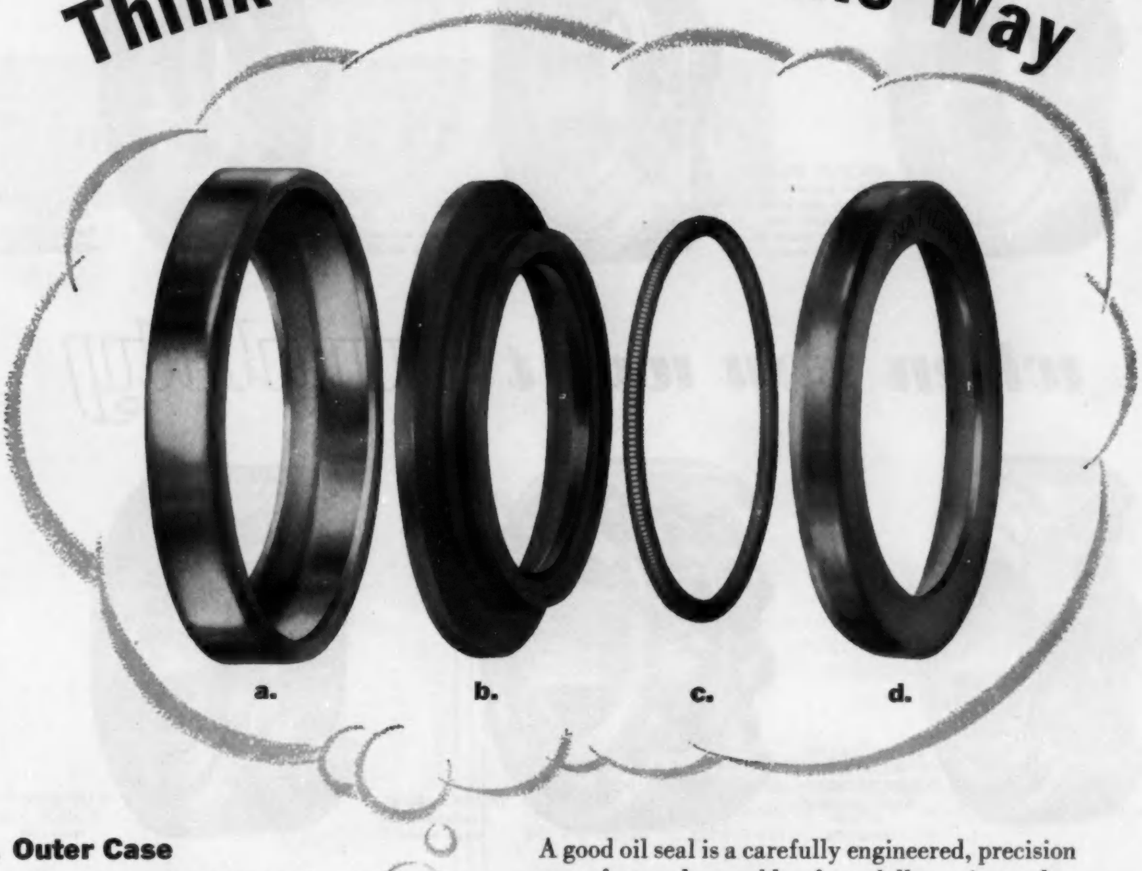


## When you design-in seals

# Think of Oil Seals This Way




### a. Outer Case

Formed to extreme close tolerance of heavy gauge steel with sufficient structural strength to maintain precision dimension.

### b. Sealing Lip

Properly prescribed material either compounded or processed for application conditions of temperature and eccentricities. Precisely molded for correct shaft interference, low torque and positive sealing.

### c. Tension Spring

Carefully engineered as to metallurgy, heat treatment and coil diameter to provide uniform compressive force on the sealing element.

### d. Inner Case

Strengthens, protects; sturdy gauge steel formed to close tolerances.

4227

A good oil seal is a carefully engineered, precision manufactured assembly of carefully engineered, precision manufactured components. Each part must be exactly right *for the given application* or the seal will not function properly.

You avoid dangers of costly retooling, remanufacture or premature replacement when seals are correctly specified during your product's design stage. Each sealing application is different; many designers use National's field engineering service to be sure correct—and latest—oil seals are used.

Why "do it yourself?" Call the National Seal field engineer now. His service involves no obligation.

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# For the Sake of Argument

## Talk of Tolerance . . .

By Norman G. Shidle

When we talk of tolerance, we talk usually of putting up with something of which we disapprove. Usually we think of tolerating some weakness or incapacity in our fellows.

This negative-type tolerance has its rewards . . . and its dangers. It often helps to by-pass fruitless arguments, or to gain us an undeserved reputation for being broad-minded. It's likely also to bring a touch of smug pleasure as we approve our own magnanimity!

The kind of tolerance that gets important results tolerates strength.

It takes only a little tactful self-control to be sympathetic with weakness. But sincerely to tolerate strengths greater than ours takes long vision—especially if we are supervisors.

To see through the person to the principle or objective takes both courage and understanding . . . and the courage waxes greater as the understanding grows.

To tolerate an action when it moves toward a goal we approve in a way that makes us uncomfortable . . . that's toleration with a punch and a purpose. It requires our reserving judgment until the action is completed . . . and rejoicing if our dire forebodings prove groundless.

Such tolerance rests in the fact that what one *is,* one never fights for. Our battles are waged for what we pretend to be . . . what has not become integrated into our personality, our being. "Proselyting," says my Philosophical Friend, "is an act designed to strengthen one's own wavering faith."

Tolerance and proselyting are mutually exclusive. True tolerance tries to help others *their* way.

SAE journal

**Norman G. Shidle**
*Editor*

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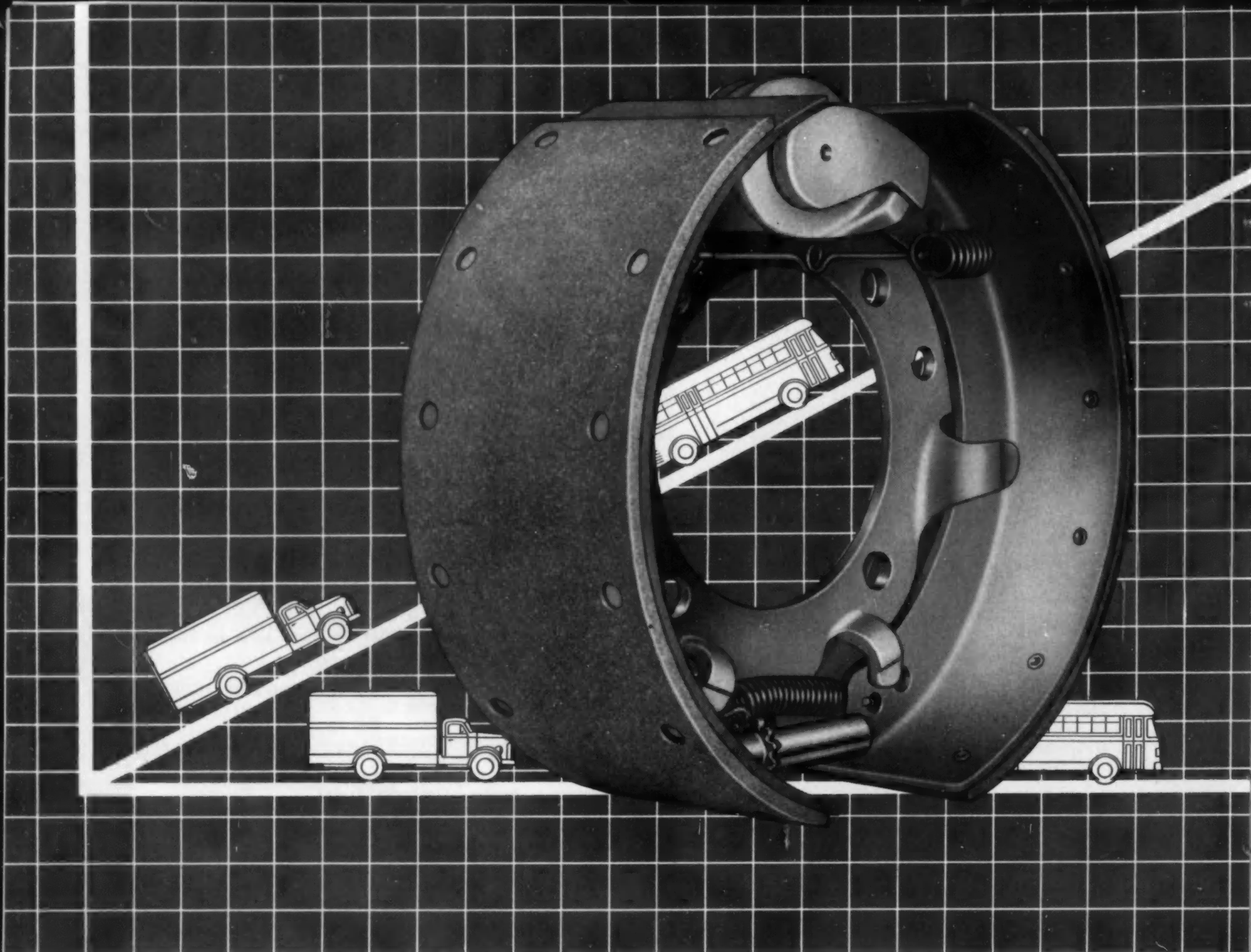
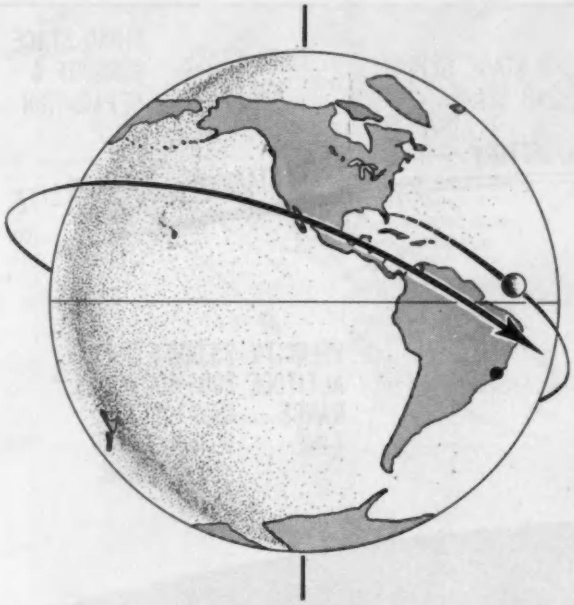


# Satellite Soon to Orbit Earth



**EARTH SATELLITE** will be launched from Air Force Missile Test Center at Cape Canaveral on the east coast of Florida. If all goes well, it should pass about over San Diego on first loop of orbiting.

Excerpts from talk by

**Rear-Admiral Rawson Bennett,**

USN Chief of Naval Research

SOMETIME during the next year, the first artificial satellite will be circling through the heavens in its own orbit, like the moon and the planets.

The earth satellite will be a globe 20 in. in diameter. Inside will be some instruments for gathering scientific information. It will be raised to a height of about 300 miles and accelerated to a speed that will keep it circling around the earth once every 100 minutes. It may stay up a day, a month, or a year.

The skin of the satellite and some of its structural parts will utilize a magnesium alloy that is very light, yet rugged enough to withstand the shock of powerful rocket firings. The skin will be about 0.026 in. in thickness. It will be completely smooth and will be polished to make it as shiny as possible so it will reflect light.

In our present stage of rocket development and with the chemical fuels presently available, a single stage rocket will not do the job. The Vanguard launching rocket will have three stages. In the design that has been selected, the first two stages will be guided. The entire rocket will be about 72 ft long and 45 in. in diameter at its widest point.

The first stage will be a liquid-fuel rocket, a modification of the Viking research rocket. Its job is primarily to serve as a large-scale booster for the other stages. The second stage is also a liquid-fueled rocket that attaches to the forward end of the first stage. It carries in its nose the third stage and the satellite itself.

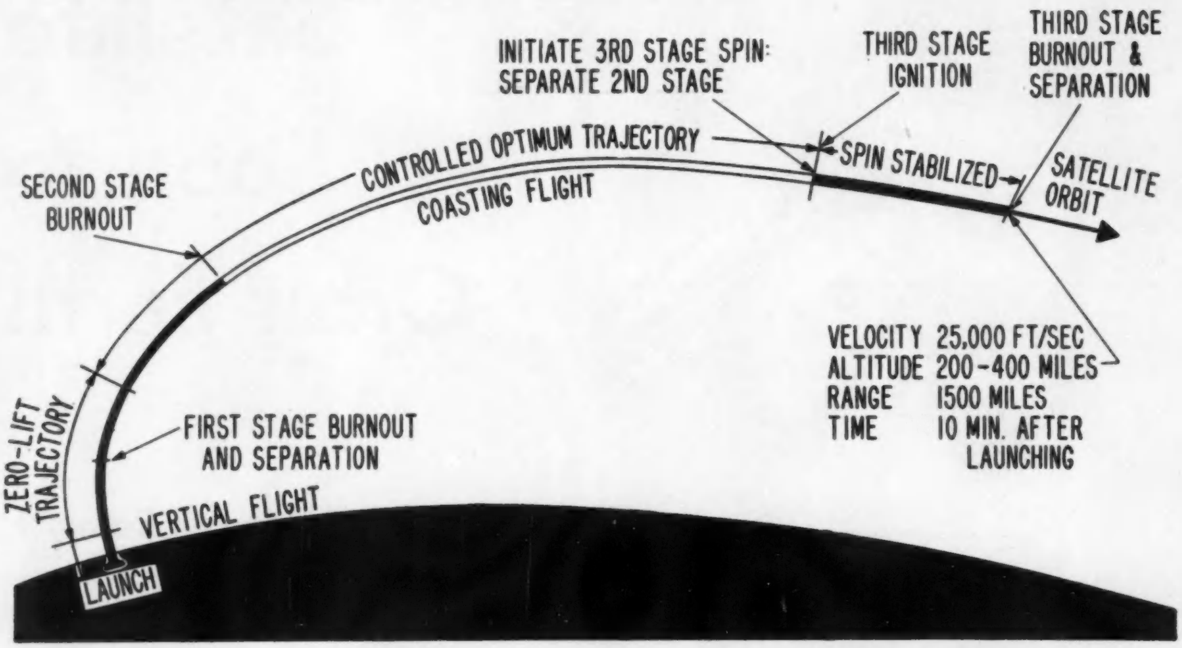
The guidance system for the whole combination is carried inside the second stage. The heart of this guidance is a series of gyroscopes that sense when the rocket is moving off course and give electronic instructions to an automatic pilot. The auto-pilot will keep the rocket on course by moving the motor on its mounting, which is a kind of universal joint, so that the thrust of the motor will push the entire vehicle in the right direction.

The third stage will be a solid-fuel rocket, accelerating the satellite up to its orbital speed after the other two stages have fired and dropped off. The 20-in. satellite, weighing about 21.5 lb and attached to the front end of the third stage, will be separated when it reaches a speed high enough to get into its orbit.

The satellite will be launched from the Air Force Missile Test Center at Cape Canaveral on the east coast of Florida, near Orlando. The three-stage rocket will take off straight up, under power of the first-stage rocket motor. About 1 mile up it will start to tilt in a smooth curve toward the southeast in the direction of its eventual orbit. The orbit will be at an angle of about 35 deg to the equator.

When it is about 26 miles above the earth, the first stage will burn out, separate, and coast to earth about 230 miles at sea. As soon as the first stage separates, the second stage rocket motor fires and pushes the satellite vehicle to an altitude of about 140 miles. When this stage burns out, the system still has enough speed to coast for about 700 miles, which will bring it up to about 300 miles above the earth. About halfway through the second stage flight, the nose cone that protected the satellite from overheating during the fast trip drops off.

During the coasting period, the two-stage vehicle will be brought into a correct horizontal position




**THREE-STAGE ROCKET** takes off straight up, under power of first-stage rocket motor. About 1 mile up it starts to tilt. First-stage burnout occurs about 26 miles above earth. Second-stage rocket pushes satellite to altitude of about 140 miles. Third stage, containing satellite, then coasts 700 miles along trajectory to altitude of about 300 miles. During coast vehicle is positioned and spin stabilized for final third-stage spurt that will impart enough speed so that centrfugal force counteracts pull of gravity and 20-in. sphere really becomes a satellite of the earth.

relative to the earth's surface. Then small jets in the third stage will start it spinning. This is to keep it stabilized, as a rifle bullet is stabilized by the spin it receives when it leaves the gun barrel.

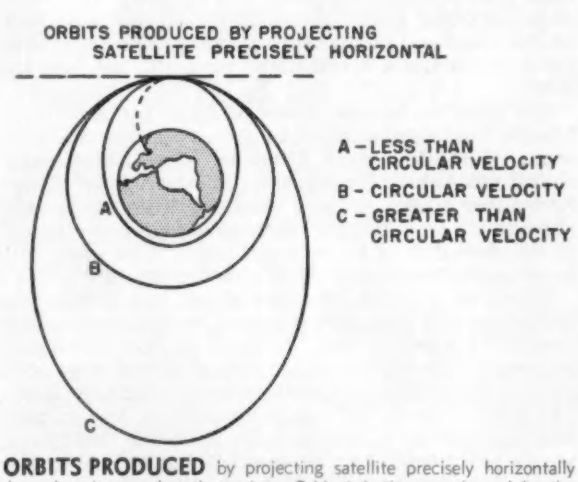
At this point the rocket is headed in a horizontal direction and travelling about 9000 mph which is half the speed needed to get it into orbit. The third stage rocket then fires and accelerates the satellite to 18,000 miles per hour. This is the fastest speed ever reached by a man-made vehicle. It will be just enough to counteract the pull of gravity to keep the satellite moving around the earth.

The orbit will not be a circle. The speed will be slightly more than enough for a circular orbit. The orbit will be an ellipse. The satellite's closest approach to earth, the perigee, will be about 200 miles. Its greatest distance from the earth, the apogee, in the case of this first satellite will be about 1500 miles.

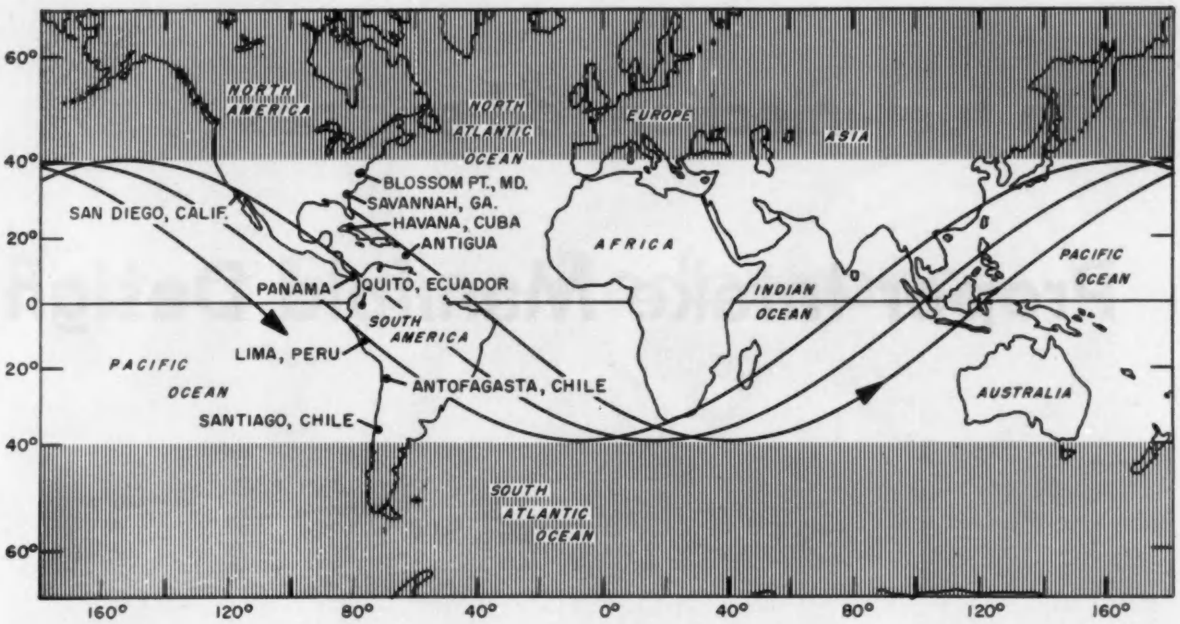
Every time the satellite approaches perigee, it will dip into the earth's atmosphere, which will act as a drag on the satellite, causing it to lose some energy and slowing it down slightly. This will happen every 100 minutes, the time it takes to make a complete circle of the earth. Gradually its speed will drop to the point where it no longer overcomes the pull of gravity, and the satellite will plunge into the denser portion of the atmosphere and disintegrate from heat, like a meteorite.

How long the satellite stays up will depend on how dense the air is at that altitude, something we don't know.

Once we get the satellite into its orbit, it must be tracked. This will be done by two methods. The first will be a radio tracking system known as Minitrack, developed at the Naval Research Laboratory. (Described on pages 30–33 of the April 1957 issue of SAE Journal.) A sub-miniature radio transmitter inside the satellite will send out signals that will be picked up by a series of tracking stations in San




**ORBITS PRODUCED** by projecting satellite precisely horizontally depend on its speed at that point. Orbit A is the one planned for the satellite to take. Orbit B is a circular orbit. Orbit C, produced by projecting at greater velocity than for circular orbit, might limit the satellite's survival to one loop.




**SATELLITE'S TRACK** will, if the vehicle survives to make enough loops, cover much of the earth from 40 deg north to 40 deg south latitude. Points named in the Americas are sites of Minitrack stations. They will pick up signals from a tiny transmitter inside the satellite. Each station will be able to check direction and velocity of the satellite and will send these data to a special computer near Washington. Here time of the satellite's passage over observing stations will be calculated and sent to them to help them pick it up optically.

Diego, along the east coast of the United States, and in South America and Australia. Each station will be able to analyze data on the direction and velocity of the satellite from signals received by its antennas and will send these data to a central electronic computer.

This computer will calculate the times of future passages of the satellite over various points, and these data will be sent out to observing stations that hope to pick up the satellite and track it with optical instruments. Much attention is being devoted to the matter of suitable cameras for this purpose. A program for volunteer observers is also being organized.

It is possible that the average person will be able to see the satellite, particularly if he is in the southern part of the United States. The satellite will be visible only if it appears in the vicinity of the observer just after sunset or just before sunrise. It will pass over from horizon to horizon in a matter of minutes. There will be little chance to spot it with the naked eye, even under the best of conditions. Common 7-50 binoculars would help.

The ultimate purpose of the Vanguard project is to create a satellite for scientific research. Many experiments could be devised for an earth satellite. Tracking the satellite may give us better measurements of the size and shape of the earth and distances between points on earth. A second output of the tracking program will be measurement of the drag on the satellite. From this we should be able to figure out the density of the atmosphere at that height.

Scientists will want to measure temperatures on the outside and inside of the satellite. Miniature temperature gages have been designed that can evaluate temperature changes from 302 to −220 F.

Ultraviolet and x-rays from the sun could be measured. This would be of interest for comparison with weather conditions on earth at the same time to see if there is any apparent correlation. Certain instruments could measure the earth's magnetic field above the atmosphere and provide us with knowledge that could be important in the field of radio communications.

Placing the first earth satellite in orbit will indeed represent an amazing scientific and technological achievement. Discoveries in chemistry have brought us the understanding needed to develop rocket fuels, and the metallurgy needed to design combustion chambers to burn them. The science and technology of electromagnetic radiation that began less than 100 years ago has given us the ability to design guidance systems and control mechanisms that do the rocket's thinking. They have given us the instruments that form the rationale for the whole satellite experiment, gathering data hundreds of miles in space, to be telemetered back. Achievements in mathematics and classical physics have nourished the work of the aerodynamist and propulsion expert.

Engineers are now moving into the Air Force Missile Test Center in Florida to set up equipment and will soon begin tests that will lead to a satellite launching attempt. The first of the series of test rockets has been fired. We are on the road toward a satellite attempt. Soon we will be actually exploring the world of space.

## With fuel-injection-fed engines . . .

# Proper Intake Manifold Design

THE intake manifold is the most significant single element affecting engine-performance characteristics of fuel-injection-fed engines. Here are some ground rules for designing an efficient intake manifold.

- Make manifold branch lengths equal wherever possible.
- Take full advantage of ram characteristics of long branch lengths.
- Select, wherever possible, manifold designs, cylinder firing orders, and numbers of cylinders such that each intake cycle is preceded and followed by a similar order of events. There is, for example, nothing more upsetting to air distribution than an uneven firing interval between cylinders.
- Make corrections and improvements in air distribution and speed characteristics by varying the tube diameters when their length cannot be varied.

To make effective use of a fuel injector, the development of the engine involves considerably more than merely providing for an injector drive mounting and installing injection nozzles. It has been found in this development work that the intake manifold is the most significant single factor influencing engine-performance characteristics. Such things as the number and the firing order of cylin-

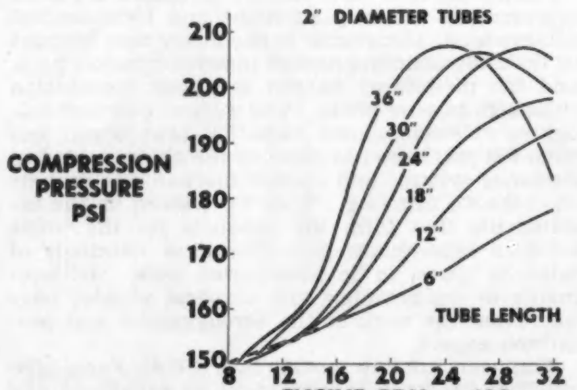



Fig. 1—As manifold intake tubes are made longer, greater volumetric filling of the cylinder takes place up to approximately 2400 rpm.

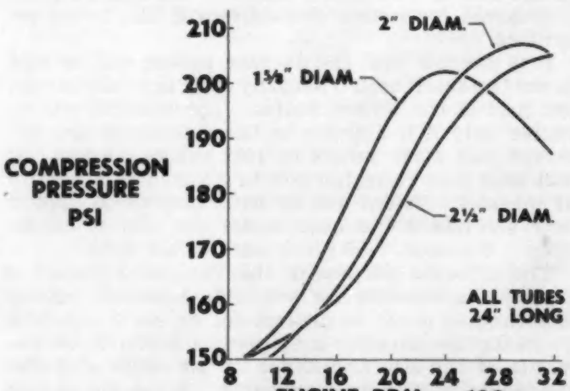



Fig. 2—Using a smaller diameter intake tube results in more favorable air-flow characteristics at the low speeds. Larger tube diameters improve high-speed cylinder filling.

# Betters Engine Performance

Based on paper by **W. F. Isley,** Continental Aviation and Engineering Corp.

ders being fed from a given intake manifold system, the size of the runners in that system, the size of the branches to the individual ports, and the respective lengths of the sections of the intake manifold are very important.

Fig. 1 illustrates the extreme importance of tube lengths and diameters to the respective cylinders. These particular data were obtained by placing simple open-end tubes of various lengths on a 5-in. bore by 4-in. stroke single cylinder. As the length of the tube was made progressively longer, it is evident that the volumetric filling of the cylinder was greater at low speed and less at high speeds. All of these data were taken with 2-in. diameter tubes.

To illustrate the effect of the diameter on airflow characteristics of an individual tube, the tube size was varied as shown in Fig. 2, which shows that the smaller tube diameter again favors the low speed while the larger tube diameters improve high-speed cylinder filling.

Since it is not always possible to have equal length tubes to all cylinders on a multicylinder engine, the distribution of air flow could be out-of-balance when using a given diameter tube with various lengths to the respective cylinders. At times, this can be counteracted by changing the tube diameter. For instance, taking data from the single-cylinder compression-pressure test, Fig. 3 shows what can be done in the way of matching tube characteristics by using two different tube diameters to get similar re-

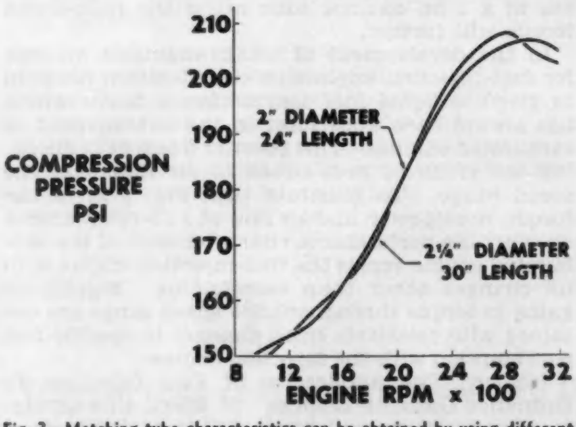



**Fig. 3—Matching tube characteristics can be obtained by using different tube diameters where different intake lengths are involved.**

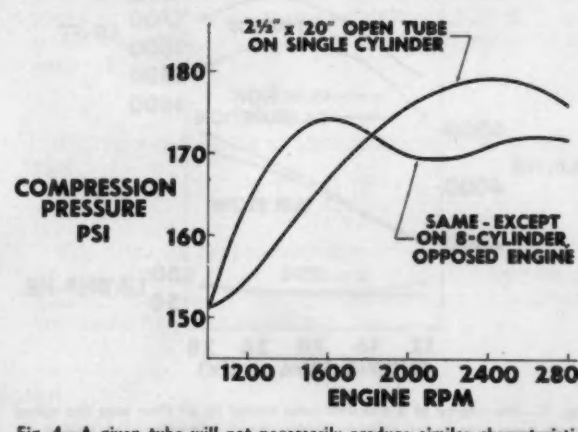



**Fig. 4—A given tube will not necessarily produce similar characteristics when placed on different engines.**

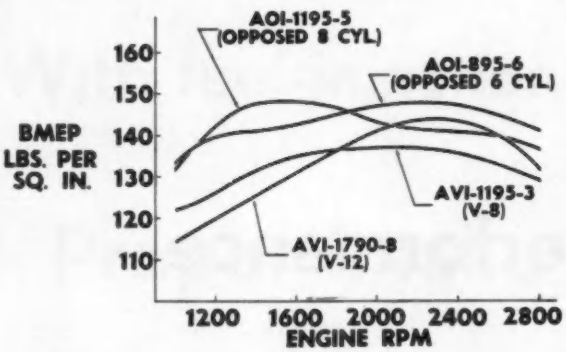



Fig. 5—Torque output is affected by cylinder firing order and the number of cylinders fed from a given manifold system. All engines had identical cylinder construction and valve size.

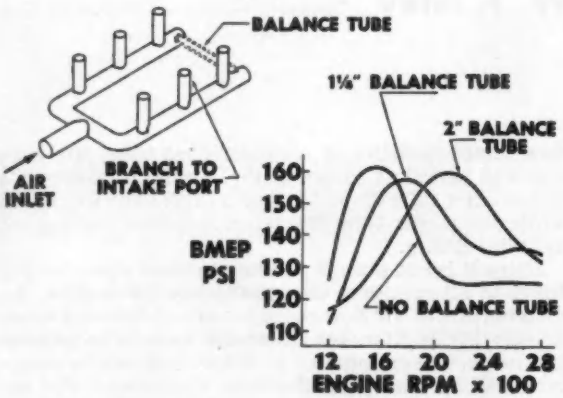



Fig. 6—The use of a balance tube between the two banks of a 6-cyl engine shifts the torque peak toward the higher speeds. The larger the diameter of the balance tube the greater the shift.

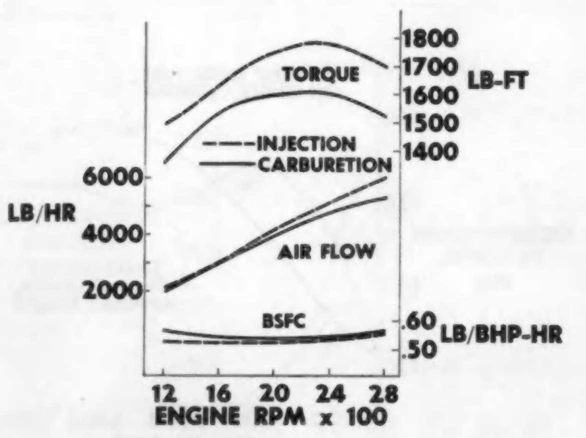



Fig. 7—The choice of a manifold best suited to air flow over the speed range gives significant gains in torque for the injection-fed engine although specific fuel consumption is approximately the same as that of the carbureted engine.

sults for different length tubes. It is evident that a long tube can be made similar in characteristics to a short tube by increasing its diameter over that of the short tube.

The air-flow characteristics of a given length and diameter of intake-manifold tube, as run on a single-cylinder engine, are not necessarily retained when applied to a multicylinder engine. This effect is illustrated by Fig. 4. A single-tube characteristic is shown, along with that of the same length and diameter tube as placed on an 8-cyl engine in a manifold in which 4 cyl of the 8-cyl engine are fed from a common system. Note that the low-speed air flow significantly increased over the single-tube system.

While a multicylinder engine manifold does not necessarily produce similar characteristics to that of the single tube, it still is true that changes in lengths or diameter can have an effect as revealed by the single-cylinder tests. Therefore, after surveying the air distribution of a given multicylinder engine, changes and improvements in that distribution can be obtained by adjusting tube lengths and diameters.

A very significant factor in the torque output produced by manifolding is the effect of cylinder firing order and the number of cylinders fed from a given manifold system. To illustrate this, Fig. 5 shows the torque curves of a 6-cyl opposed engine, 8-cyl opposed engine, 8-cyl V-engine, and 12-cyl V-engine, all having identical cylinder construction and valve sizes. These engine designs, however, all had various firing orders, firing intervals, and manifolds which produced the drastically different torque curves shown.

A powerful factor in affecting torque on a given manifold is accomplished by using balance tubes between various parts of the system. Fig. 6 illustrates the effect of balance tube sizes between two banks of a 6-cyl opposed engine which had a common intake pipe to each bank with short connecting tubes to the respective cylinder ports. This shows that the torque without any balance tube between the two sides is very high at low speed and poor at mid-and-high-speed ranges. The addition of a 1¼ in. diameter balance tube between the banks shifts the torque peak slightly to the high-speed end, and the use of a 2-in. balance tube raises the high-speed torque still further.

In the development of intake-manifold systems for fuel-injection engines no consideration needs to be given to liquid fuel distribution, a factor which has always been uppermost in the development of carbureted engines. This permits freedom in choosing the manifold best suited to air flow over the speed range. To illustrate this, Fig. 7 gives the torque, horsepower, and air flow of a 12-cyl V-engine showing the performance characteristics of the carbureted engine versus the fuel-injection engine with no changes other than manifolding. Significant gains in torque throughout the speed range are obtained with relatively small changes in specific fuel consumption with the injection engine.

(Paper, "The Application of Fuel Injection To Ordnance Gasoline Engines" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# Designing a Forged Steel Crankshaft

Based on paper by **Harold F. Wood,** Wyman-Gordon Co.

THE design of a forged steel crankshaft to produce the most economical engine is obtained by a cooperative effort between the engine designer, the tool engineer, and the forging engineer. The engine designer must have in the crankshaft the characteristics that will give desired engine performance and dependability. The tool engineer must have a crankshaft that lends itself to most economical machining and balancing with minimum rejections. The forging manufacturer must have a crankshaft design that can be made economically.

This cooperative effort has made definite contributions to basic crankshaft design, forgeability, and machineability and has resulted in substantial cost savings that otherwise would not have been possible.

The modulus of elasticity and the endurance limit of the crankshaft material have a major effect on crankshaft design if the proper bending rigidity and ratio of maximum allowable stress to the endurance limit of the material are to be obtained. The effect of these material properties on crankshaft design is shown in the following simple analysis of each.

## Effect of Modulus of Elasticity on Crankshaft Design

The following simplified analysis shows how the modulus of elasticity of the crankshaft material affects the required thickness of the critical section of the crankshaft throws. The bending rigidity of the critical sections is maintained by changing their thickness. Suppose a crankshaft is designed with the following:

$d$ = Thickness of the critical section
$b$ = Width of the critical section
$I$ = Moment of inertia of the critical section
$E$ = Modulus of elasticity of the material
$M$ = Bending moment in the crank throw
$L$ = Effective length of the crank throw as a beam

Bending deflection is proportional to:

$$\frac{ML^2}{EI}$$

and:

$$I = \frac{bd^3}{12}$$

Therefore bending deflection is proportional to:

$$\frac{12ML^2}{Ebd^3}$$

Suppose initial conditions are represented by letters having suffix "0" and new conditions with a lower modulus of elasticity by suffix "1." If $M$, $L$, and $b$ are the same, the bending deflection remains the same if:

$$\frac{1}{E_0 d_0^3} = \frac{1}{E_1 d_1^3}$$

The new thickness of the critical section is therefore:

$$d_1 = d_0 \sqrt[3]{\frac{E_0}{E_1}}$$

Fig. 1 shows graphically the effect of the modulus of elasticity of the crankshaft material on the required thickness of the critical sections to maintain the same bending rigidity.

## Effect of Endurance Limit on Crankshaft Design

The following simplified analysis shows how the endurance limit of the crankshaft material affects the required thickness of the critical sections of the crankshaft throws. The ratio of maximum allowable stress to the endurance limit of the material in the critical sections is maintained by changing their thickness. It is assumed that the crankshaft is designed for the maximum allowable stress and that

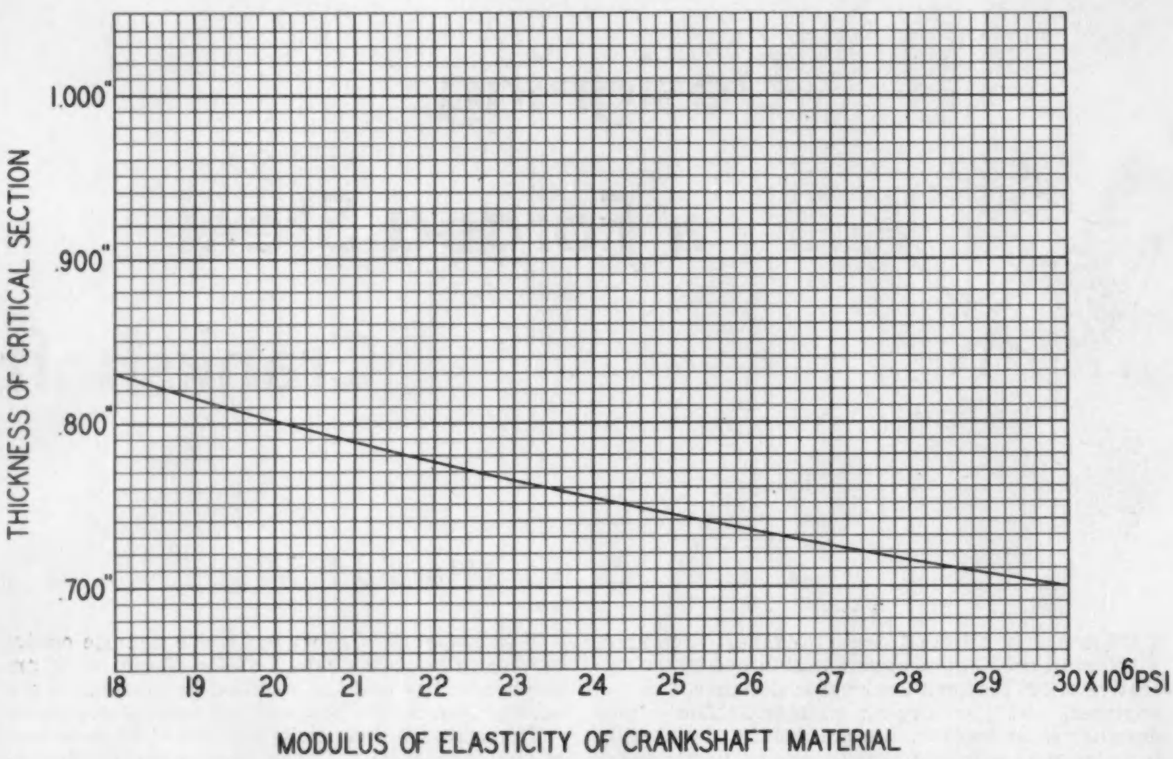



Fig. 1—Effect of the modulus of elasticity on critical sections.

this is produced by bending in the crankshaft throws. Suppose a crankshaft is designed with the following:

$d_0$ = Thickness of the critical section
$b_0$ = Width of the critical section
$Z_0$ = Section modulus of the critical section
$M_0$ = Maximum bending moment occurring in the critical section
$s_0$ = Maximum allowable stress
$p_0$ = Endurance limit of the material

Then:

$$s_0 = \frac{M_0}{Z_0}$$

and:

$$Z_0 = \frac{b_0 d_0^2}{6}$$

Therefore:

$$s_0 = \frac{6M_0}{b_0 d_0^2} \qquad (1)$$

Now suppose the maximum allowable stress is reduced to $s_1$ but the maximum bending moment in the critical section remains the same. Then the section modulus has to be increased, say to $Z_1$. Suppose the new conditions are represented by letters having suffix "1."

Then:

$$s_1 = \frac{M_0}{Z_1}$$

and:

$$Z_1 = \frac{b_1 d_1^2}{6}$$

Again:

$$s_1 = \frac{6M_0}{b_1 d_1^2} \qquad (2)$$

Since we are going to compensate for the reduction in maximum allowable stress only by increasing the thickness of the critical section then:

$$b_1 = b_0$$

So dividing equation 1 by equation 2:

$$\frac{s_0}{s_1} = \frac{d_1^2}{d_0^2}$$

Taking the maximum allowable stress to be some fixed proportion of the endurance limit of the material:

$$\frac{s_0}{p_0} = \frac{s_1}{p_1}$$

or:

$$\frac{s_0}{s_1} = \frac{p_0}{p_1}$$

Combining this with equation 3:

$$\frac{p_0}{p_1} = \frac{d_1^2}{d_0^2}$$

The new thickness of the critical section is therefore:

$$d_1 = d_0 \sqrt[2]{\frac{p_0}{p_1}}$$

Fig. 2 shows graphically the effect of the endurance limit of the crankshaft material on the required thickness of the critical sections to maintain

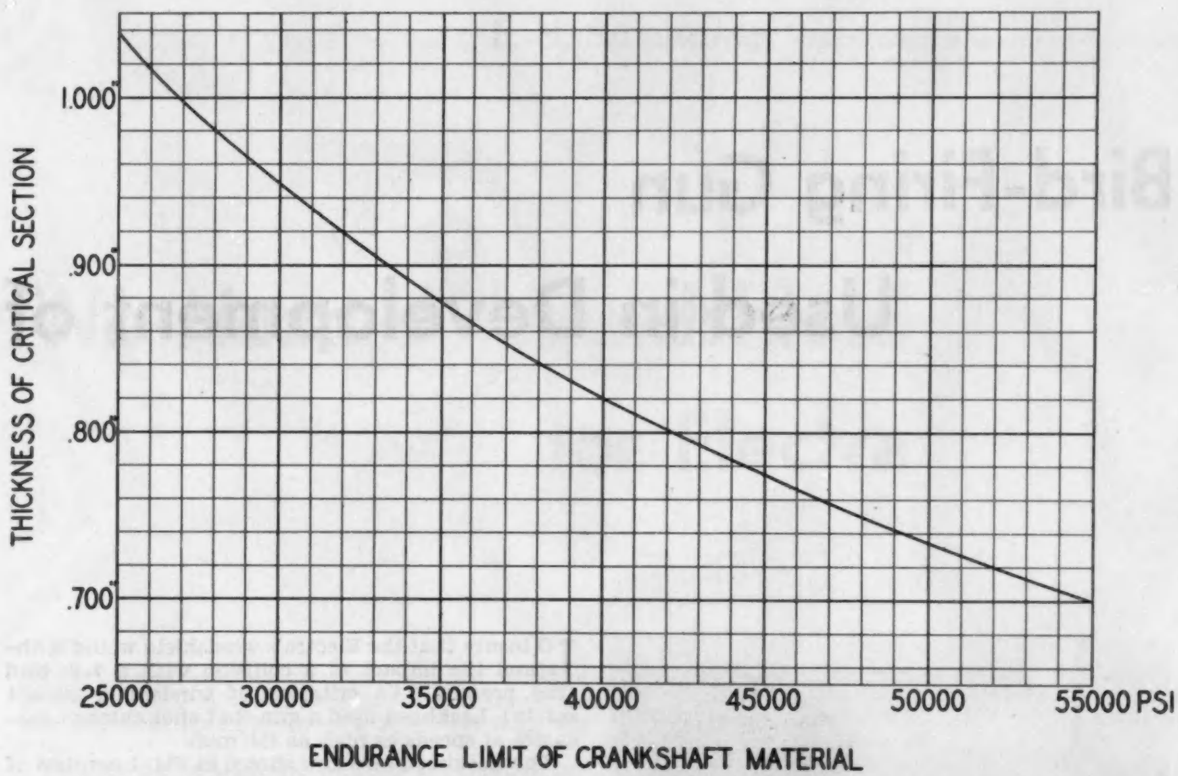



**Fig. 2—Effect of the endurance limit on critical sections.**

the same ratio of maximum allowable stress to the endurance limit of the material.

Some improvement can be made in the properties of the critical section by increasing the width by using oval contours. Reference to the formulas for moment of inertia and section modulus shows that such additions are much less effective than increasing the thickness.

## Evaluating a Crankshaft Material

The proper evaluation of a crankshaft material is fundamental if that material is to make possible desired engine performance characteristics and dependable service.

The important properties are yield point, tensile strength, ductility, modulus of elasticity, and endurance limit. These properties should be determined from test pieces taken from the crankshaft itself and several crankshafts should be tested from different heats of materials. This procedure will give a true picture of the uniformity of these properties from heat to heat, from crankshaft to crankshaft, and from section to section of the same crankshaft.

Several crankshafts should be tested by macroetch and micrographically to determine the nature of the structure in critical areas and to insure freedom from injurious internal defects. These tests should be made on both longitudinal and transverse specimens taken from the critical areas throughout the length of the crankshaft.

Experimental crankshafts, made in accordance with preliminary design, should be tested in static bending and torsion with stress coat or strain gages to determine stress concentration factors and tested in a suitable fatigue testing machine to determine the endurance properties of each individual section of the crankshaft.

Experimental engines are assembled and torsional vibration surveys are made to determine the harmonic characteristics of the engine both with and without a vibration damper.

The engines are then given dynamometer endurance runs at critical speed until failure of the crankshaft or other component. The critical speed is the speed previously determined by the torsional vibration surveys at which maximum deflection in degrees double amplitude occurs. If some component part fails before the crankshaft, another engine is assembled with the same crankshaft and the test continued provided inspection shows it has not been damaged or failure already started. The performance of the crankshaft in the endurance tests of the engine is the most important factor in the evaluation of the crankshaft from the standpoint of both basic design and material.

(Paper "Forged Steel Crankshafts" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# Bird-Firing Gun

# Used in Development of

Fig. 1—Lockheed bird gun shoots chicken carcasses at windshields to test impact properties.

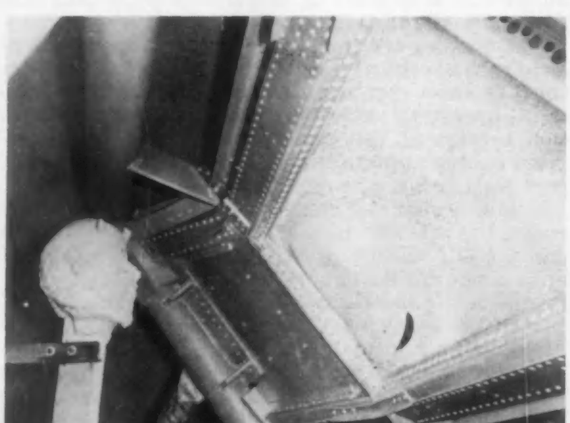


Fig. 2—Flying glass mutilates face of clay head when windshield is hit by 4.1 lb bird at 345 knots.

TO insure that the Electra's windshield would withstand the impact of a collision with a 4-lb bird (the present CAA criterion of windshield impact safety), Lockheed used a gun that shot chicken carcasses at speeds as high as 450 mph.

The Lockheed bird gun shown in Fig. 1 consists of a tank, barrel, loading breech, and quick-opening valve. The 20 cu-ft tank is capable of operating at pressures up to 175 psi. The 5-in. ID brass barrel is 20 ft long and has been carefully honed to a mirror finish on the inside.. The highly polished surface of the gun barrel is necessary to prevent mutilation of the bird.

A chicken carcass is placed in a cheesecloth sack and inserted into the breech of the gun. This is followed by a 2-in. wad of Lockfoam. A plug is then screwed into the breech to close it. Just below the gun breech is the quick-acting valve which consists of a mylar plastic diaphragm clamped between two pipe flanges. The diaphragm thickness requirement varies with the pressure being used. A stack of 0.003, 0.005, and 0.007 in. mylar discs is used to get the required diaphragm thickness, and 0.017 in. is required when operating at a tank pressure of 175 psi. A pointed rod is inserted through a small hole at the top of the gun breech to "fire" the gun by puncturing the diaphragm.

Bird speeds up to 450 mph have been obtained with this particular gun arrangement. Speeds are recorded by measuring the time interval for the bird to pass between two photo-cells spaced 6 in. apart at the end of the barrel. A rough approximation of speed is also obtained by measuring pressure versus time at orifices placed 10 ft apart along the barrel. A specially constructed Quonset hut welded from ¼ in. steel plates is provided to act as a backstop.

The first shot showed that windshields of the type satisfactory for slower aircraft were not adequate for the high cruising speed of the Electra. The ½-in. fully tempered plate glass was expected to break into thousands of pieces but adhere to the soft vinyl core that actually stops the bird. However, a

Excerpts from paper by **E. H. Spaulding,** chief structures engineer, Lockheed Aircraft Corp.

# *"No-Hazard"* Windshield for Electra

shower of high velocity glass splinters was directed at the location of the pilot's face which would do him nearly as much harm as a direct hit from the bird.

This shower of glass was entirely unexpected, because it had never occurred previously during development of the Constellation windshield. It appears that the higher bird velocity injects so much energy into the glass that its bond to the vinyl is not sufficient to retain the small pieces. Fig. 2 illustrates the loss of glass in the region directly behind the area of bird impact and its mutiliating effect on the fine features of a clay head placed in the pilot's seat position. This damage was caused by a 4.1 lb chicken fired at 400 mph.

It was found that flying glass could be eliminated by the addition of a thin layer of vinyl placed directly behind the main load-carrying pane. A good optical surface, however, dictates that a hard, flat, transparent material be used on the inner face of the windshield, and so an additional thin layer of Sierracin was added to the window. Fig. 3 shows what happened after this windshield was struck by a 4.2 lb bird at 362 mph. The glass broke into thousands of small pieces as usual but was entirely retained by the thin layer of vinyl behind it. The Sierracin cracked into larger pieces, but for the most part remained attached to the vinyl. A face drawn on thin paper and wearing glasses had been placed directly behind the windshield and sustained practically no damage from the few light Sierracin particles that managed to break loose from the added vinyl layer.

A cross-sectional view of the Lockheed "no-hazard" windshield is shown in Fig. 4.

(Paper "Trends in Modern Aircraft Structural Design" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

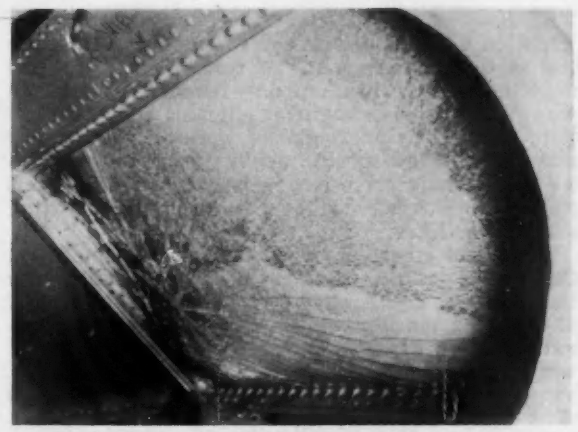


Fig. 3—The "no-hazard" shield contains all glass fragments.

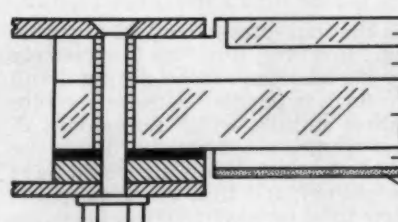
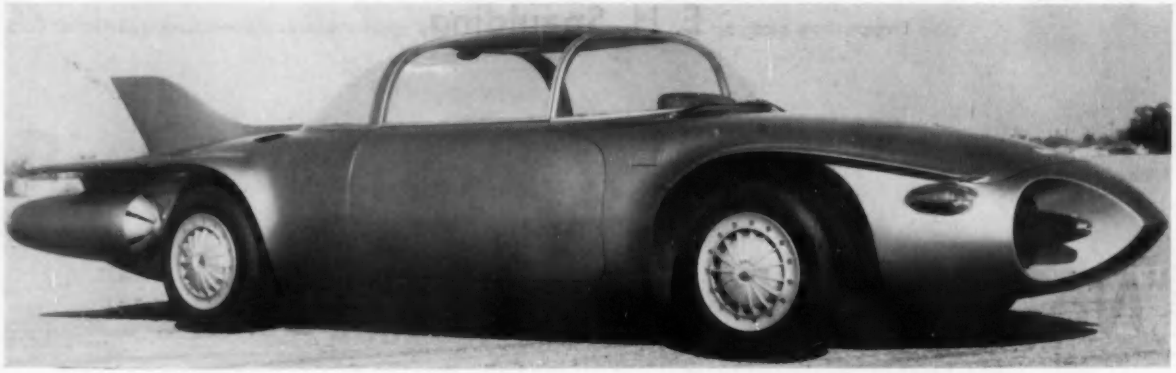



Fig. 4—"No-hazard" windshield has a 0.125 in. layer of vinyl to catch fragments of glass and a 0.06 Sierracin layer to satisfy optical requirement for a hard inner face.



# Putting Titanium Feathers

THE body of the turbine-powered Firebird II, exhibited as the "family car to the future" in the GM Motorama, was made of resin-bonded, formed titanium sheet. Titanium, only recently available in sheet stock large enough for efficient body fabrication, offered the challenge of working with a new material. Its low specific weight was promising and its tremendous corrosion resistance would permit leaving the exterior surface unpainted, thus creating a unique body.

The sheet stock, prepared by the Republic Steel Corp., was designated as RS 40 commercially pure titanium. It had a yield strength (0.2% offset) of 40,000 psi, a tensile strength of 50,000 psi, and elongation in 2 in. of 20%. It was of 0.040-in. gage, 48 in. wide by 120 in. long. A special sheet of 0.050-in. gage, 65 × 106 in. was rolled for the hood panel and deck lid.

Titanium sheet can be blanked or cut. It can be formed by bending, stretching, drawing, or spinning. The difficulty encountered is similar to working stainless steel or high alloy aluminum, but certain very definite restrictions made the problem of fabrication more difficult than if using these more common alloys.

Hand forming is the time-proved method of prototype body shaping. However, titanium is extremely liable to pick up surface impurities during hand hammer shaping. Such impurities cause very severe cracking of the sheet surface, which no amount of hand finishing can eradicate completely. From the outset it was evident that hand forming would have to be kept at a minimum, and that the usual panel flanging would have to be severely restricted because of tooling limitations.

Consideration was next given to the joining and fastening of the formed panels. Fastenings which are visible on the exterior are unfashionable, hence the choice was limited to welding or using the relatively new technique of resin bonding. Tests proved that structurally sound welds could be made in inert gas environment with sheets of the chosen gage. The general appearance of the welds could be made acceptable (free from pits or flaws) after surface grinding. A slight surface discoloration was always visible, therefore the decision was made to keep welds to a minimum on the visible surfaces.

## Development of Resin Adhesive

In preparation for resin bonding, the electrochemistry department of the GM Research Staff was assigned the work of developing a resin-type adhesive to meet the following tentative requirements:

1. Capable of adhering titanium to itself, steel, aluminum, and stainless steel.
2. Cure at temperatures of 200 F or less with low bond pressure.
3. Adequate shear and tensile strength in temperatures from − 20 F to 200 F.
4. Resistant to flexural fatigue, impact, and bending in the temperature range.
5. Capable of application by skilled personnel under assembly room conditions.

The most satisfactory adhesive, designated GMR 3206-2, was based on epoxy resins modified with Thiokol elastomer and filled with asbestos. Its strength properties average about 3000 psi in shear at room temperature. Tests indicated that the bond material thickness after curing should not exceed 0.010 in.

## Forming the Panels

The usual full-size clay model of the body shape was prepared. From this plaster casts were taken. A plaster model was formed from the casts, essentially reproducing the clay model surfaces. This was carefully hand worked, using faired steel tem-

Based on paper by **Robert F. McLean,** General Motors Corp.

# on the Firebird II

plates. This accurately finished plaster form was the basis of the panel tooling program.

Preliminary tests showed that titanium panels would have to be hot formed at least at 700 F on heated tools. The simplest known method to meet these limits was to cast forms of Kirksite alloy and hand finish them to dimension, hence a complete set of casts of the master plaster model was made to predetermined panel cut lines. Kirksite forms for hydraulic stretcher press use were cast from these.

Forming the specially rolled sheet was basically simple, but considerable skill was required. The tools were placed in a gas-fired oven and heated to a maximum allowable temperature of 600 F. The tool was then positioned on the bed of a 300-ton capacity hydraulic stretcher press. While placing the tool, the sheet was furnace heated to 920 F, accompanied by a bright golden color. When the proper sheet heat was reached, the sheet was clamped quickly in the stretcher jaws and pulled over the form.

Only one to three such operations per sheet were possible and such factors as tool and sheet cooling, stretch tension, and tool shape combined to make the forming task difficult. A certain amount of final shaping to the tool form by power hammering was found to be possible. Following this, the fit on the master plaster model was checked and small corrections made.

The elementary nature of the tooling eliminated the usual flanging at panel edges. In lieu of that the panels were bandsaw cut to trim lines after forming and the task of fitting to the steel structure was begun. Tests had shown that very sound welds could be made by heliarc torch with an inert gas shield, but since weld lines could not be removed completely by burnishing, it was decided to fit adjacent panels in a butt joint of 0.005 in. maximum opening and resin bond them to the supporting structure.

Comparative tables of physical properties fail completely to indicate the armor-like toughness exhibited by titanium sheet. Panels could scarcely be recontoured, edges could barely be reshaped. A panel that could be fitted and trimmed in an hour in other metals required a day or more in titanium. Any attempt to hand form a part to precise fit risked the danger of surface cracking, which would spoil the appearance of an entire piece. These experiences do not indict titanium as an auto body material, rather they reflect the elementary tooling and methods.

### High Finishing with Abrasive Blocks

The complex body shape precluded a mechanical finishing of the panels with proper grain flow—closely paralleling the natural highlighting of the surface—so hand finishing was undertaken. Special friable abrasive finishing blocks were used to obtain the "brushed" grain. These were composed of ground pyrex glass particles bonded with rigid foam plastic. This was about the only abrasive material which would cut satisfactorily by hand application. Following this operation, the surface was thoroughly cleaned and given a light coat of wax to prevent fingerprinting.

Although there have been no actual road service experiences, the body has withstood well the vibrations of trailer-truck shipment to all parts of the country, and no body failure has resulted from the strenuous handling of the show model. When a panel was properly shaped it was extremely rigid and had it been necessary to achieve high structural efficiency, considerable loads could have been carried by the outer skins. Moreover, resin bonding appears to be adequate to transmit appreciable forces.

(Paper, "Titanium Feathers for the Firebird II" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# New Knock Ideas Aid

NEW ideas about knock and antiknock action are being developed that may help serve as a basis for putting engine-fuel relationships on a rational foundation.

A few of these ideas—which are based on an analysis of ignition delay data from a rapid-compression machine and of peak temperatures and pressures in a motored engine—are:

1. A "mild" engine rates sensitive fuels high because its design provides high end gas pressures as well as temperatures.

2. Knocking depends on two basic factors:
   (a) Ignition delay properties of the fuel-air mixture, which are characterized by the "chemical" octane number of the fuel.
   (b) Thermal gradients in the end gas, which depend on engine design and are related to the "mechanical" octane number of the engine.

3. Tetraethyl lead shows antiknock properties only when it is decomposed before the fuel autoignites. The rate of decomposition depends solely on temperature, unlike ignition delay, which depends on both temperature and pressure.

## Fuel Sensitivity and Engine Severity

An approach to the problems of fuel sensitivity and engine severity has been made by attempting to relate two factors: the properties of the fuel-air mixture as shown from ignition delay data, and the temperatures and pressures reached by the compressed gases in an engine. Thus, in the case of diisobutylene-air mixtures, it has been possible to explain why such engine factors as increased air temperature and higher engine speed tend to reduce the octane rating. This work implies that engine design factors which result in higher end gas temperatures must also involve higher pressures, if engines are to appreciate sensitive fuels. Examples of factors which promote engine mildness on this basis are improved combustion-chamber design (which permits high temperatures and pressures due to increased compression ratio without increase in octane requirement) and higher volumetric efficiency (which permits higher pressures at the same temperature).

*Fuel Sensitivity*—Fuel sensitivity, in its general sense, describes the fact that a fuel may give wide variations in octane number, depending on the engine test method used.

Diisobutylene is an example of a sensitive fuel. We have found that it is possible to interpret this sensitivity in terms of ignition delay data.

Fig. 1 shows the relative ignition delay between diisobutylene and isooctane for a wide range of peak temperatures and pressures. On this plot are shown lines of constant delay ratio identified by numbers, where values greater than one indicate that diisobutylene has a longer ignition delay than isooctane. The converse is true for numbers smaller than one. Thus, the entire area is separated broadly into two regions. At the higher temperatures and pressures diisobutylene has a longer ignition delay than isooctane and would, therefore, be expected to knock less than isooctane. The reverse would be true in the other region.

In order to relate this basic ignition delay information to the behavior of the two hydrocarbons in engines, accurate pressure-time data (from which temperatures can be calculated) have been obtained in two other motored engines under several conditions. The temperature-pressure paths, which the diisobutylene-air mixtures in the combustion chamber follow when they are subjected to compression ratios just below autoignition in the engine are plotted in Fig. 2 on the background derived from Fig. 1. With this information, it is now possible to make a rational interpretation of the behavior of the two fuels in motored engines.

Consider curve A, obtained with diisobutylene at a compression ratio of 9.8 and an inlet mixture tem-

# Engine—Fuel Studies

Based on paper by **E. B. Rifkin** and **C. Walcutt,** Ethyl Corp.

perature of 400 F. Practically all the temperature-pressure path for this condition lies in the region where isooctane shows longer delays than diisobutylene. It would, therefore, be predicted that isooctane under the same engine conditions would not be stressed to the autoignition limit. Thus, the compression ratio could have been increased without autoignition if isooctane had been used instead of diisobutylene, which is another way of saying that the octane number of diisobutylene is less than 100 under these conditions. Actually the rating was 86. Going on to curve B, which describes the behavior of diisobutylene just below its autoignition-limited compression ratio when the inlet temperature is 200 F, the pressure-temperature path goes through both regions. Because some account must be taken of the contributions toward autoignition in both regions, it cannot be predicted from these data which fuel will rate better under these conditions. However, it can be said that diisobutylene will rate far better here than it does when the inlet temperature is high. This is borne out by the data, which show a rise from 86 to 99 "octane" numbers as the inlet temperature is reduced. A third example of this kind is shown on curve C, which pertains to an autoignition-limited test with diisobutylene in a motored engine run at a manifold pressure of 30 psia. Because the peak of this curve is well within the area corresponding to longer delays for diisobutylene than for isooctane, one would again predict a high rating for diisobutylene. This prediction is also validated by the engine data given in Table 1.

**Table 1—Autoignition-Limited Compression Ratios (890 rpm, 150 F inlet air, 30 psia manifold pressure)**

| Fuel | Compression Ratio |
|---|---|
| Isooctane | 9.4 |
| Diisobutylene | 11.0 |

*Engine Severity*—The term "engine severity" is used to describe the fact that engine conditions affect the ratings of sensitive fuels. Thus an engine or engine condition which gives a low rating to a sensitive fuel is called "severe," while a "mild" engine gives a high rating to a sensitive fuel. Thus, engine severity and fuel sensitivity are closely related, and one would expect that it might be possible to clarify some aspects of engine severity based on ignition delay concepts, as has already been done for fuel sensitivity.

Useful examples of changes in engine severity are found in the effects of air temperatures and of engine speed on the ratings of diisobutylene in the General Motors single-cylinder knock-rating procedure. Thus, increasing the speed from 600 to 2000 rpm (at an air temperature of 150 F and a jacket temperature of 350 F) depreciates the rating of diisobutylene from better than 100 to 86. The knock-limited compression ratios at which these ratings were made were 7.3 and 5.7, respectively. At the high-speed conditions, the peak pressure must drop considerably, because of the reduced volumetric efficiency and the lower compression ratio. The peak temperature probably changes very little, because increases in speed at constant compression ratio cause moderate temperature increases, which are probably compensated for by the decrease in compression ratio. Fig. 1 shows that a marked drop in pressure with little change in temperature causes the fuel-air mixture to shift toward the region where isooctane rates better than diisobutylene. Thus, the rating of diisobutylene drops as the speed increases, and it is clear that the severity of the engine at high speed is due to the reduced peak pressures.

A similar change from a mild to a severe engine condition occurs when the inlet air and jacket temperatures are raised and the knock-limited compression ratio is lowered at constant speed. Again, this change probably reflects the reduction in peak pressure with minor changes in temperature. Thus, the

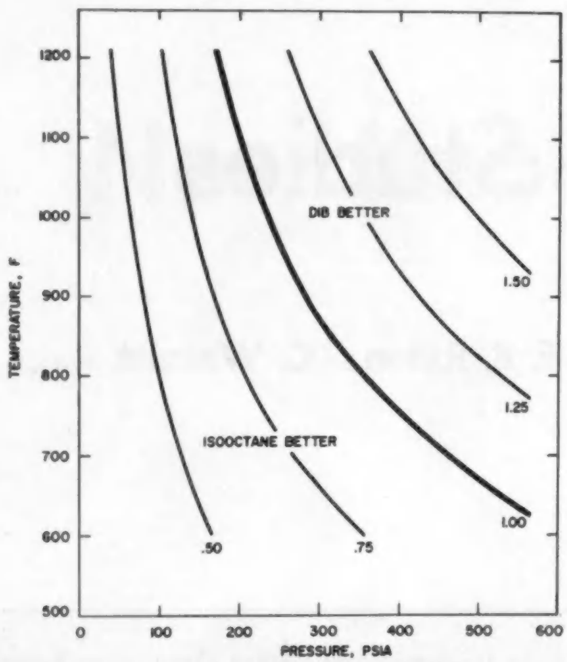



Fig. 1—Relative ignition delays between diisobutylene and isooctane for a wide range of peak temperatures and pressures. Lines of constant delay ratio are shown. Values greater than one indicate that diisobutylene has a longer ignition delay than isooctane. Converse is true for numbers smaller than one.

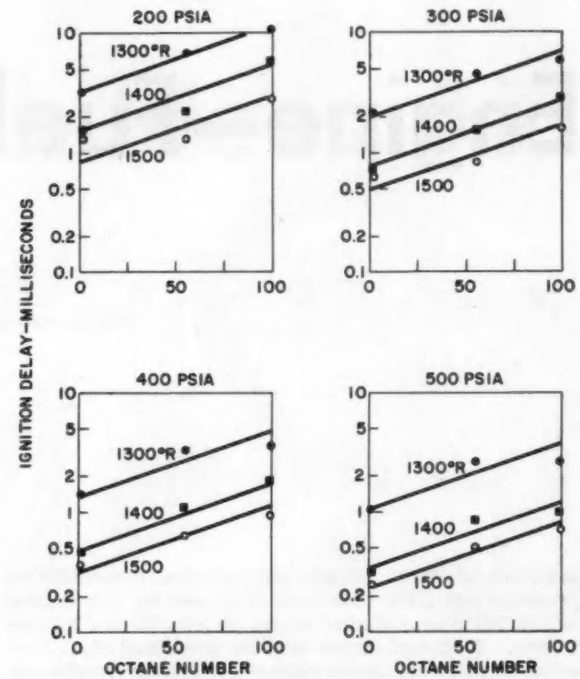



Fig. 3—Ignition delay of primary reference fuels in terms of octane number.

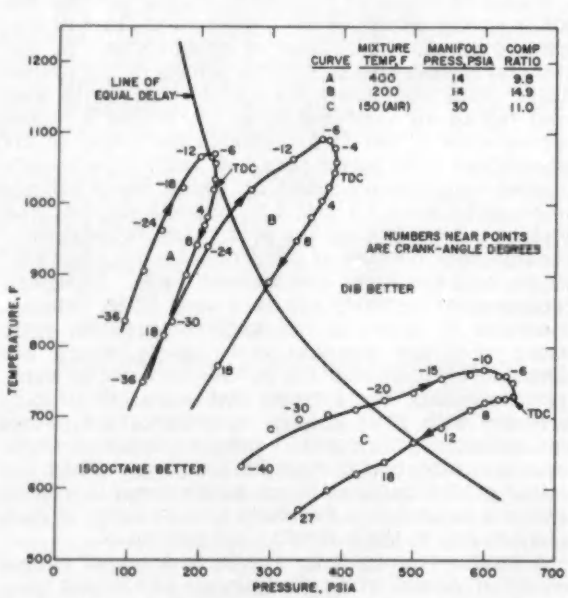



Fig. 2—Autoignition-limited pressure-temperature paths in motored engine. Diisobutylene. Fuel-air ratio: 0.066.

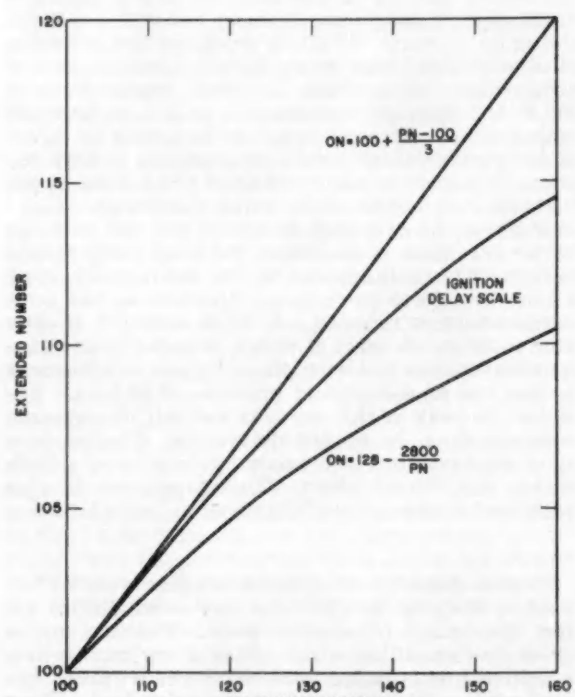



Fig. 4—Octane scale extensions.

severity that accompanies the high inlet and jacket temperatures is due to the reduced peak pressures in the end gas.

Clearly, the ultimate aim of this type of approach would be to predict what factors affect the sensitivity of commercial fuels, and to determine which factors in engine design and operation influence relative degrees of severity and mildness. Unfortunately, the present work is only an indication of what might conceivably be done along these lines. Further advances will require the accumulation of ignition delay data on fuel blends of commercial interest as well as a better understanding of the effects of operating variables on mixture ratio and on the temperature and pressure of the end gas during knock rating. Nevertheless, from what has been accomplished to date, it appears that the processes occurring in the rapid-compression machine are quite similar to those which are of interest in engines, and that further studies of this type can possibly be of very great usefulness in providing a better understanding of the knocking behavior of fuels in engines.

## Knock

The practical implication of our analysis is that there are two basic ways by which to control knock in engines. One is to use fuels and additives to increase the ignition delay, thereby retarding the initiation of autoignition. This method of control involves what might be termed "chemical octane numbers." The other method is to design the combustion space in such a way as to increase the magnitude of thermal gradients within the end gas. The existence of thermal gradients does not necessarily imply a cooler temperature in the end gas and a consequent loss of power. It is reasonable to suppose that a part of the high antiknock value obtained by combustion-chamber turbulence is due to the establishment of thermal gradients in the mixture. Antiknock improvement achieved in this way involves what might be termed "mechanical octane numbers."

*Ignition Delay Properties*—Fig. 3 is a series of plots relating the logarithm of the ignition delay period to the octane number of the fuel for stoichiometric mixtures of air with normal heptane, 55-ON primary reference fuel, and isooctane. These relationships are shown over a wide range of temperatures and pressures, typical of those in the end gas of a fired engine. A remarkable correlation among all these data exists, as shown by the fact that a line of constant slope can be drawn through each series of data irrespective of temperature or pressure, within the reliability of the individual values of ignition delay for each fuel. The slope of this line (0.00556 per octane number) shows that the ignition delay for isooctane is always 3.6 times as long as that for n-heptane. This indicates a constant percentage increase in ignition delay as the octane number changes, and shows that each octane unit increase represents an increase of 1.29% in the ignition delay.

Because of the constant *percentage* involved, the *actual* increase in ignition delay period becomes larger as octane numbers increase. This is a mathematical way of expressing what has long been known by engine-fuel technologists, namely, that octane numbers become "larger" in terms of engine parameters as octane numbers approach 100. For example, assuming that units of ignition delay are the best measure of antiknock quality, an octane number at the 100 level is almost twice as large as an octane number at the 50 level. Based on the reasoning that ignition delay is a fundamental property of a fuel, it is possible to envision a knock-rating scale in which unit changes in rating correspond to unit changes in ignition delay. This affords an opportunity to see what properties such a scale would have above 100. Fig. 4 shows how such a scale relates to other scales which have been used for antiknock quality above 100 octane number. It is interesting that the scale based on ignition delay agrees with the

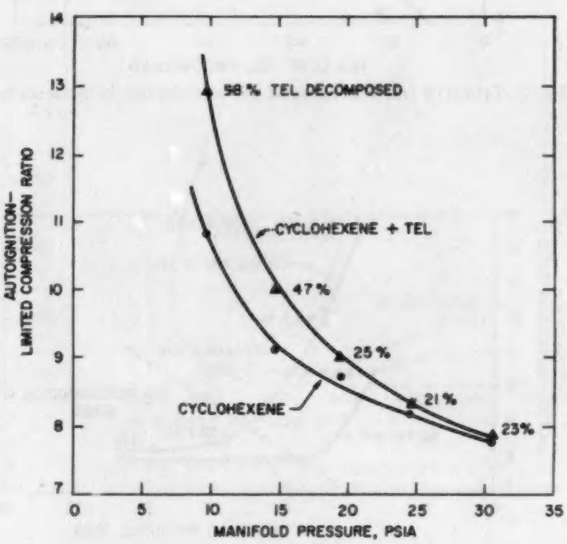



Fig. 5—Tetraethyl lead effectiveness in cyclohexene. Evaluation based on engine parameters.

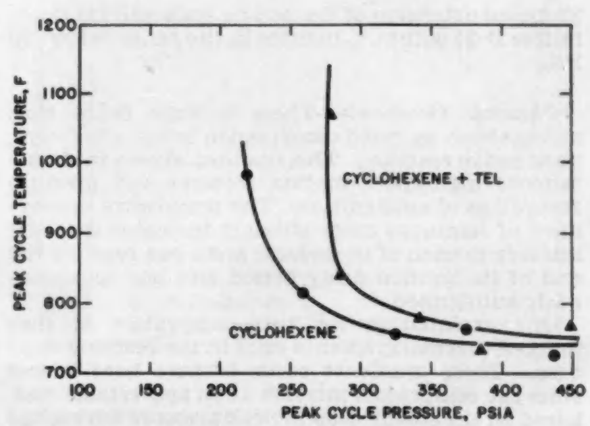



Fig. 6—Tetraethyl lead effectiveness in cyclohexene. Evaluation based on peak cycle temperatures and pressures.

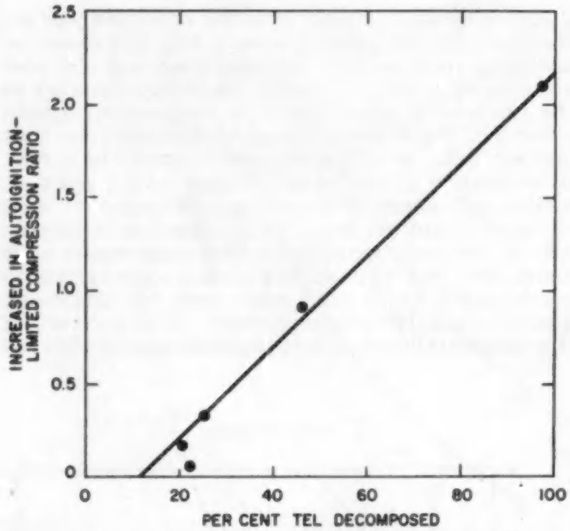


Fig. 7—Tetraethyl lead decomposition and effectiveness in cyclohexene.

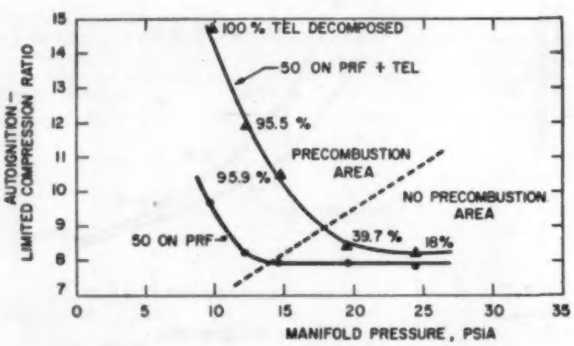


Fig. 8—Tetraethyl lead effectiveness in 50-octane-number primary reference fuel. Evaluation based on engine parameters.

proposed extension of the octane scale (ASTM Committee D-2) within ½ number in the range below 120 PN.

*Thermal Gradients*—There is little doubt that autoignition by rapid compression is not a uniform, progressive reaction. This has been shown in simultaneous high-speed motion pictures and pressure recordings of autoignition. The progressive appearance of luminous spots strongly indicates that the mixture in each of these local areas has reached the end of its ignition delay period and has spontaneously autoignited.

One explanation for this observation is that marked thermal gradients exist in the reacting mixture. These gradients occur because heat is lost from the compressed mixture at an appreciable rate, based on the steady drop in peak pressure during the delay period (heat transfer coefficient of 0.015 Btu per sec-ft$^2$-F). It would naturally be expected that the point at which self-ignition begins would be the hottest part of the mixture, since pressure gradients are not likely to persist for an appreciable length of time. Areas which are somewhat cooler than the hottest point will require a longer ignition delay, and the result will be a succession of autoignitions which occur at times dependent on the temperature distribution throughout the mixture.

## Knock is an Autoignition Reaction . . .

It appears, therefore, that knock in engines is an autoignition reaction occurring under conditions where the thermal gradient is sufficiently small to allow the autoignition to "propagate" at very high speed and produce pressure oscillations similar to those observed in the rapid-compression machine. These conclusions regarding the mechanism of autoignition and knock are in essential agreement with the ultra-high-speed photographs of combustion obtained by Miller. These photographs showed that relatively slow autoignition reactions were followed by a much faster explosion. It was pointed out that the speed of these explosions was supersonic and therefore they might be true detonation waves. With the concept of presensitized autoignition reactions occurring in a mixture having an existing thermal gradient, the speed of the autoignition is limited only by the chemical kinetics of the reaction process. Thus, we can explain the observation of a wave moving at a speed greater than that of sound in a presensitized fuel-air mixture without assuming the existence of a detonation wave.

## Tel Effectiveness

A great deal of study, in both motored and fired engines, has shown that the rate of decomposition of tel depends only on the temperature of the gases in the combustion chamber, and is independent of such factors as pressure, fuel, and other additives. If the temperature is low, little decomposition will occur. Thus, it would appear possible to select engine conditions so that tel will decompose considerably before the fuel autoignites (high temperature, low pressure) or so that hardly any tel will decompose before autoignition (low temperature, high pressure). In this way we should be able to discover what effect tel decomposition has on autoignition of the fuel-air mixture.

Studies of this kind were first carried out using cyclohexene as the fuel in a motored engine. A study of the effect of inlet manifold pressure (Fig. 5) showed that the autoignition-limited compression ratio increased as the manifold pressure was reduced from the peak value of 30 psia. When tel was added to the cyclohexene, no effect was observed at the high manifold pressure. However, a marked effectiveness of tel in raising the autoignition limit was obtained at lower manifold pressures. These results imply that the effectiveness of tel shown at low manifold pressures where the compression ratios (and the peak temperatures) were relatively high, was due to the fact that tel decomposed before the ignition delay expired for the clear fuel. Conversely, the ineffectiveness of tel at the high manifold pressures, where the compression ratios (and therefore

the peak temperatures) were low, is due to the lack of decomposition of tel under these conditions.

Another way of showing the change in effectiveness of tel is in terms of the peak cycle temperatures and pressures which can be tolerated without autoignition by the fuel-air mixture with and without tel. These data (Fig. 6) show that a peak temperature of almost 800 F must be reached before tel begins to be effective in allowing the fuel to reach even higher temperatures without autoigniting. At the high manifold pressures, where cyclohexene autoignites at a peak temperature below 800 F, little effectiveness of tel was observed.

The specific relation between the amount of tel decomposed and its effectiveness in raising the autoignition-limited compression ratio is shown in Fig. 7. As expected, conditions which promote tel decomposition also promote tel effectiveness. The relationship indicates that the first 10% of the decomposed tel is not effective. This can be explained as follows. When only small amounts of tel are decomposed in this type of test, it is inevitable that they will be decomposed late in the cycle. Since we know that very small amounts of tel can be very effective in conventional knock ratings, this result must imply that there is some finite time required for the decomposed lead to exert its effectiveness. This "delay period" and the specific chemical and physical changes which the lead compounds undergo at this time are obviously of great practical importance and are under close study.

We conclude from these tests that, in cyclohexene, decomposition of tel is essential if it is effectively to inhibit the reaction which leads to autoignition.

In order to make this conclusion more general, it was decided to carry out a similar investigation with a typical fuel which shows extensive precombustion reactions. Such a fuel is a 50-octane blend of primary reference fuels. The data obtained (Figs. 8–10), support the conclusion that tel must be decomposed to be effective. The essential difference between tel effectiveness in the two fuels has to do with the peak temperatures obtained when engine conditions are changed. With cyclohexene, lowering of the manifold pressure and raising of the compression ratio resulted in a gradual increase in peak temperature and therefore in tel decomposition. However, with the 50-octane blend, a point was reached where precombustion reactions suddenly caused a large jump in peak temperature and in tel decomposition. Although tel did show some effectiveness in the region of no precombustion reaction, where up to 40% of the tel was decomposed, its greatest effectiveness was seen in the region where the heat liberated by precombustion raised the temperature and caused essentially complete decomposition of the tel.

## An Interesting Relation

The comparison of tel effectiveness in cyclohexene and in the 50-octane blend shows an interesting relation. In the high-pressure region, where neither fuel exhibits precombustion, tel is more effective in cyclohexene than in the 50-octane blend. However, in the low manifold pressure region, where temperatures are high and where the 50-octane blend has extensive reactions, tel is less effective in cyclohexene than in the blend of primary reference fuls. Although this hardly constitutes proof, there is an indication that the existence of precombustion reactions can induce greater tel effectiveness, probably by means of higher temperatures and greater tel decomposition. Other factors may also be involved, but they are unknown at the present time.

(Paper, "A Basis for Understanding Antiknock Action" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

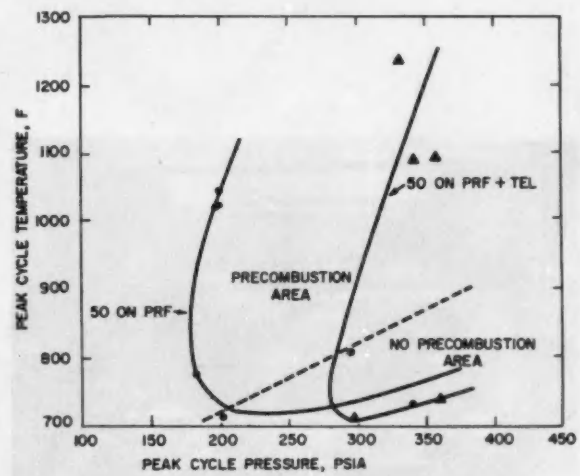



Fig. 9—Tetraethyl lead effectiveness in 50-octane-number primary reference fuel. Evaluation based on peak cycle temperatures and pressures.

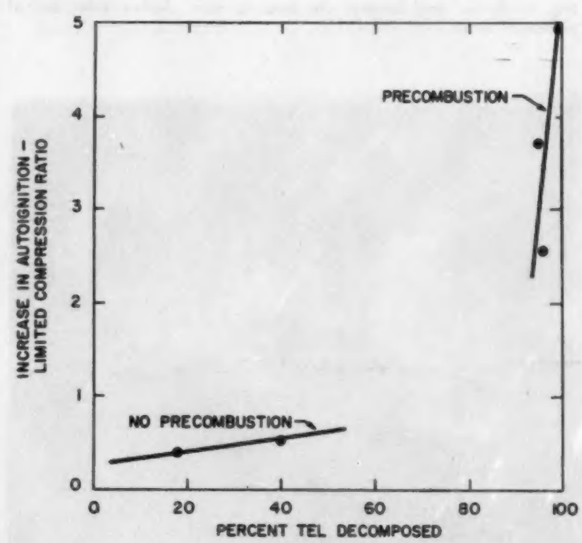



Fig. 10—Tetraethyl lead decomposition and effectiveness in 50-octane-number primary reference fuel.

# Plastic Tooling —*Quality*

Fig. 1—Plastic drop-hammer die used to form shallow trays out of aluminum sheet.

PLASTIC tooling is increasing in popularity—the reasons: lower costs, shorter tooling times, and quality tools. It has some disadvantages too, but these do not offset the advantages afforded the tool shop where long-run production is not required.

There are many examples illustrating the advantages of plastic tooling. Let's take a look at a few of them. Fig. 1 shows a drop-hammer die used to form shallow trays out of 75 SO aluminum sheet. The dies cost about one-fifth that of steel dies of a similar design. They were delivered in one-third of the time normally required and over 9000 automobile body parts have been stamped out with them.

Savings of approximately 25% in production costs and 40% in delivery time resulted from the use of epoxy resin compounds to face the huge draw dies shown in Fig. 2. This was an experimental die for an advanced automobile luggage compartment cover panel. Only six weeks were required to produce the die as compared with eight

Fig. 2—Huge draw dies faced with epoxy resin compounds cut production costs and delivery time.

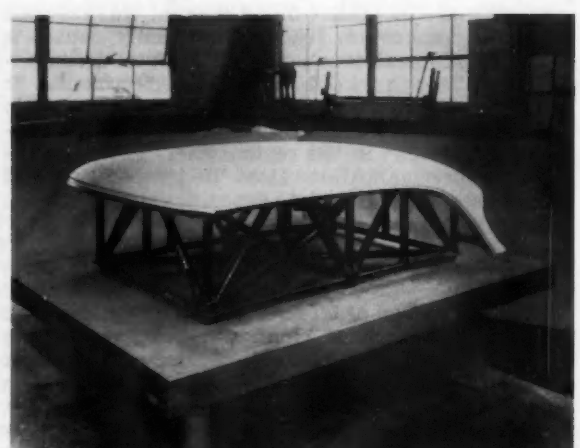


Fig. 3—Master Keller model of a car roof panel.

Based on paper by **Bruce E. Godard,** Bakelite Co., Division of Union Carbide and Carbon Corp.

# At Less Cost

to ten weeks had the panel been made entirely of a zinc alloy casting. Had cast iron been used, at least twelve weeks would have been required. Cold-rolled, low carbon steel, 0.036 in. thick is formed on the die which consists of a zinc alloy core faced with approximately ⅜ in. of tough epoxy. Both the cavity and the punch are made in the same way.

Epoxies are used to construct master Keller models which far surpass wood or plaster for dimensional accuracy, both initially, and in maintaining that accuracy throughout the useful life of the tool. A master Keller model of a car roof panel, such as shown in Fig. 3, requires tolerances from 0.002 to 0.005 in. The model was made from room-temperature-curing compounds and is much lighter in weight than the original mahogany master. The important feature of this particular model is the maintenance of the exact dimensions, within small tolerances, under constantly changing atmospheric conditions and in the face of the normal wear and tear of shop handling.

A master Keller model such as this fits into a complete program when epoxy jigs and fixtures are cast directly from its surface. An example of this is the spot welding jig shown in place in Fig. 4. Exactness in the jig is ensured by direct lay-up—and this technique eliminates time consuming hand barbering and finishing.

Lower weight in plastic tools means less worker fatigue in handling these tools. It also allows larger one-piece dies, jigs, or fixtures to be constructed. Typical of lower weight tools is the body side master Keller model shown in Fig. 5. The model is easily handled by two men although it covers the entire body side. Incidentally, this particular sample underwent a stability check lasting more than two years. It was stored in a cold room at 20 deg below zero, exposed to rain, snow, and ice, and was placed in a humidity oven for six weeks at 90 C and 80% humidity. At the end of these tests, dimensional variation was less than 0.003 in.

Easily duplicated epoxy models and molds pro-

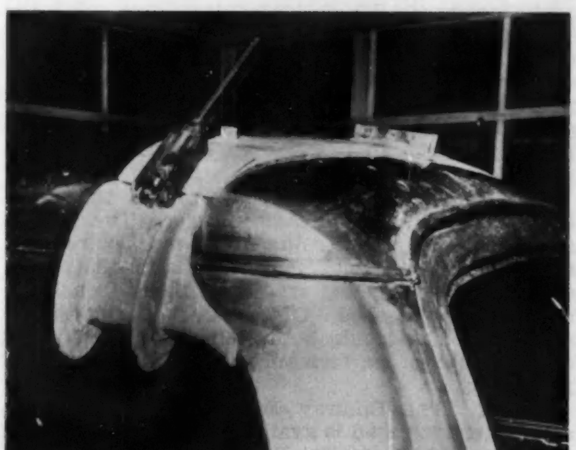


**Fig. 4—Exactness in this spot welding jig is ensured by direct lay-up. This technique eliminates hand barbering and finishing.**

**Fig. 5—The low weight of plastic tools permits two men to easily handle a body side master Keller model.**

vide an exact copy of all tools at the start of production. This means that all departments can have a model available without waiting several weeks for use of the one master model. This advantage works out production snags early—before costly mistakes are made. It can also allow production to be started while further development work takes place and tooling is completed on long-run steel dies.

The ease of modifying plastic tools is a definite advantage in die development and prototype work. Changes in design draw characteristics can be quickly and easily accomplished—sometimes right on the presses.

The disadvantages of plastic tooling must not be overlooked. Plastics will probably never completely replace metal dies for long-run production. Though extremely durable, they are not hard enough to stand up under large production runs. Of course, it is always possible to indefinitely prolong the life of the plastic tool by repeated, inexpensive resurfacing.

Another disadvantage of epoxy tooling is that certain hardening agents used in curing the resins cause skin irritation. This condition is primarily a matter of individual susceptibility and to date has not caused much difficulty. Adequate ventilation, change of clothing, and proper and frequent washing of exposed areas are effective control measures.

The high exothermic heats generated by curing epoxy resins have also caused problems in casting large dies. The problem can be alleviated with fillers of many types and improved casting techniques. The fillers disperse the heat repidly, as well as cut down the amount produced. Other techniques include the use of backing materials to reduce the section undergoing the exothermic action.

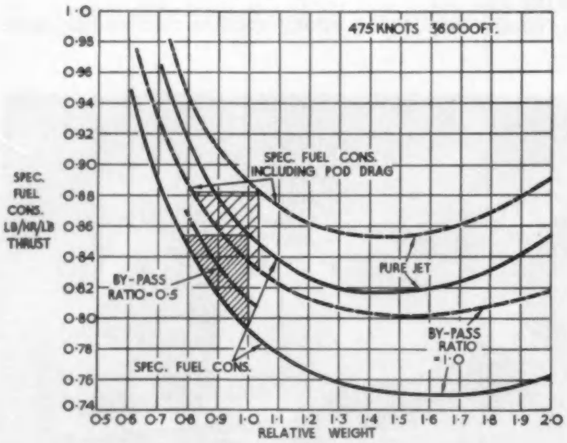
(This abridgment is based on a paper presented as part of a round table on "The Place of the Plastics Industry in Automobile Body Design and Construction.")

# BYPASS ENGINE . . .

## . . . for high-subsonic long-range civil air transports, as exemplified by the Rolls-Royce Conway, has a slight but valuable fuel economy advantage over straight turbojets.

Excerpt from paper by **A. A. Lombard,** Aero Engine Division, Rolls-Royce, Ltd.

THE bypass improves propulsive efficiency in the cruising speeds under consideration by producing a lower jet velocity than that of the simple jet without compromising the cycle efficiency of the engine. Of course, the pure jet can be made to operate at a low flame temperature to give the same order of jet velocity as that of a bypass engine, but only by compromising its cycle efficiency.




**The relative weight and specific consumption for engines having bypass ratios of 0, 0.5, and 1 indicate a saving in weight of 15% at a given specific consumption, or a reduction in specific consumption of 5½% at the same weight when using a bypass ratio of 0.5. This is only slightly modified when the additional pod drag is taken into account.**

A most precise design comparison can be made between the two types—designed with the same skill, same mechanical and aerodynamic duty, same efficiency assumptions and the same materials. The scale factors are precise so that weight and performance can be accurately predicted. The result expressed against a range of turbine inlet temperatures shows for the bypass engine, either a superiority in consumption at a given flame temperature, or a superiority in regard to weight at a given fuel consumption, as shown in the accompanying chart. In practice an intermediate value would be selected.

This comparison has been made many times and it always produces the same answer. The gain is small but it is a definite one, and it must be realized at this stage of development of the aircraft turbine engine that such gains are very difficult to achieve by any other method. Of course, it is a degree of superiority that could be overshadowed by aspects outside that of performance, particularly that of reliability.

(Paper "The Conway Engine" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# Don't Overlook
# Low-Frequency Stresses
# In Designing
# Small Gas Turbines

Based on paper by **Gordon Sorenson** Continental Aviation and Engineering Corp.

IN analyzing strength of rotating parts of gas turbines, don't overlook the 100–10,000 cycles portion of the S–N curve. Continental's investigations show that parts may fail due to low-frequency fatigue even though they pass the usual checks for extended fatigue and for steady stresses.

Continental is using experimental stress analysis to fill the gap between the designer and the endurance testing of engines. The size effect in the small turbine influences stresses in terms of such things as:

1. Shaft speeds which go up as turbine size goes down.
2. An increase in the frequency of vibrating stresses to beyond 10,000 cps.
3. Increase of *g* loads on strain gages fastened to

Fig. 1—Compressor rotor hub has complicated juncture of slot and counterbore.

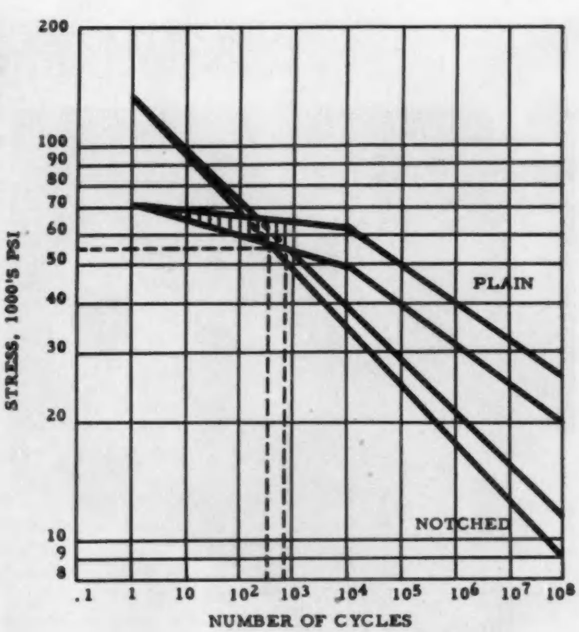



Fig. 2—Stress versus number of loading cycles (S-N) curve for 14ST forged aluminum.

turbine blades to beyond 80,000 $g$'s as shaft speed goes up.

4. Small fillet sizes at the points of high stress, making smaller strain gages necessary.

The measurement of stresses therefore becomes proportionately more difficult as the size of the turbine decreases.

For accuracy in determining loads and stresses both static and dynamic tests are conducted. These tests involve the primary tools of the trade: bonded wire strain gages, brittle lacquer, and associated equipment.

During the development of small gas turbines, three basic categories of stress problems were encountered. They are: (1) steady stress, (2) low frequency stress, (3) high frequency stress.

1. Steady state or static stress is a stress produced in the structure and held for a period of time, usually many hours. The static stress can be produced in a bolt in the assembly of an engine, in a turbine or compressor rotor due to centrifugal force, or by differential expansion of heated parts. The steady state stress can cause fracture of parts upon first application of load if true tensile strength of the material is exceeded. Besides, it can cause creep at stress levels below the true tensile strength if the temperature of the material rises too high. Creep can deform a part to the point of its malfunction or produce eventual stress-rupture.

2. Low frequency stress is considered to be stress which fluctuates frequently enough to accumulate between 100 and 100,000 cycles during the service life of a part. Components such as shafts, gears, and other moving parts receive low frequency stress cycles from stopping the engine or changing speeds. Figured from the squares of the speeds, the centrifugal stress range imposed is 80–90% of the maximum stress in going from idle to maximum speed.

3. High frequency stress is a vibratory stress that is cycling at a frequency such that millions of cycles will accumulate in the life of an engine. In small turbines the high frequency stress areas are usually in the turbine or compressor blades or discs, which may be vibrating at 1000 cps or higher. This type of vibration is serious when resonance is encountered at operating speeds and can be the most troublesome stress problem in the development of a gas turbine.

A stress analysis program demonstrated the existence of three basic categories of stress systems and how they could be controlled.

Low frequency fatigue life of a rotor was evaluated for allowable starts and stops. The stress at the juncture of the slot to the counterbore (Fig. 1) is very complex due to the radial concentration from the counterbore and the tangential concentration from the slot. If the concentration is severe enough the material will yield in tension locally when going up in speed. Residual compression will be induced on decreasing speed. Measurements made on the slot with strain gages indicated a stress concentration of 1.1. Residual stresses measured in the bore and slot of a specimen rotor that had been spun to 46,000 rpm indicated that the slot was retaining a compressive residual stress of 10,000 psi while the bore retained 12,000 psi. These were indications that the slot by itself was not much of a stress concentration.

A severe notch in ductile material does not weaken the structure for the 1st to the 100th cycle, but beyond this range plasticity is lost and fatigue failures do occur. The fatigue strength decreases rapidly compared with the plain specimen.

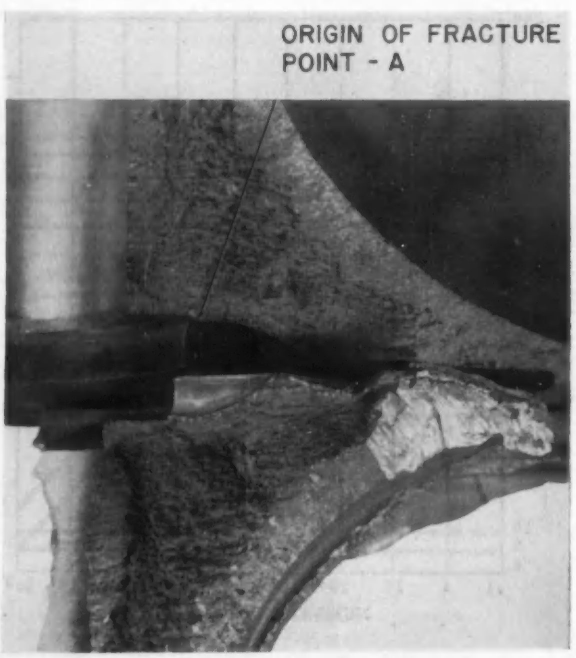



Fig. 3—Compressor rotor was cycled to fracture in spin pit. Fracture started at juncture of slot and counterbore.

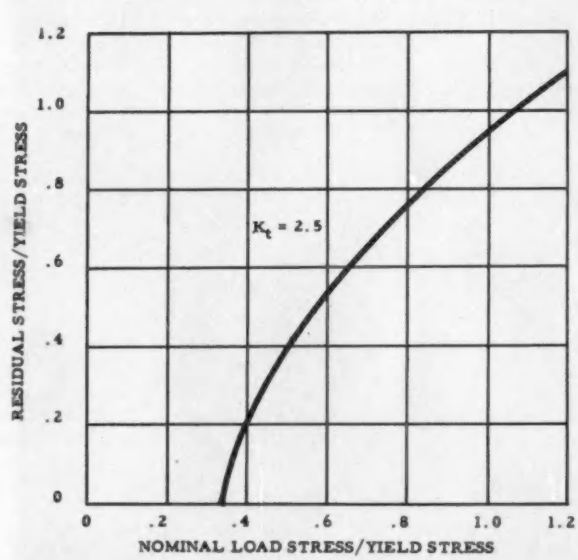



Fig. 4—Nominal stress at notch as a function of induced stress at notch.

From spin pit tests, the burst speed of the forged 14ST rotor was 52,000 rpm and corresponds to the true tensile strength of the material or 71,000 psi, Fig. 2. Sufficient ductility was present to accommodate plastic flow requirements at the notch and allow the material to develop its true tensile strength at the bore of the rotor. Spin pit tests were initiated in order to cycle the rotor up to its yield strength and back to idle. Since the yield strength of the material was 55,000 psi, the equivalent rotor speed was calculated to be approximately 46,000 rpm.

Two wheels of the 14ST material with 8–11% elongation were cycled in the spin pit from 10,000 to 46,000 rpm and back to 10,000 rpm until fracture occurred. The first rotor burst at 1101 cycles and the second rotor burst at 620 cycles. Fig. 3 shows the appearance of the fracture. Examination of the fracture shows the origin to be at the junction of the slot and counterbore, Point A, Fig. 3. The fracture showed evidence of progressive failure or fatigue. Fatigue tests on the rotor correlated with the allowable-cycles-to-failure data (Fig. 4) for severely notched specimens.

The S-N curve, Fig. 2, was based on cycles of completely reversed stress, whereas the rotor was cycled in one direction. This apparent discrepancy disappears when the induced stress at the notch is considered. If the nominal load stress reaches the yield stress in a notched specimen and the load stress is removed, the residual compressive stress induced is 95% of the yield stress, Fig. 4. The best load cycle for all practical purposes, produces completely reversed stress in the notch.

Since the junction of the slot and counterbore was established as the critical point, a rework procedure, Fig. 5, and proof spinning at 46,000 rpm were established to reduce the stress concentration and induce a favorable residual compressive stress after the final machining.

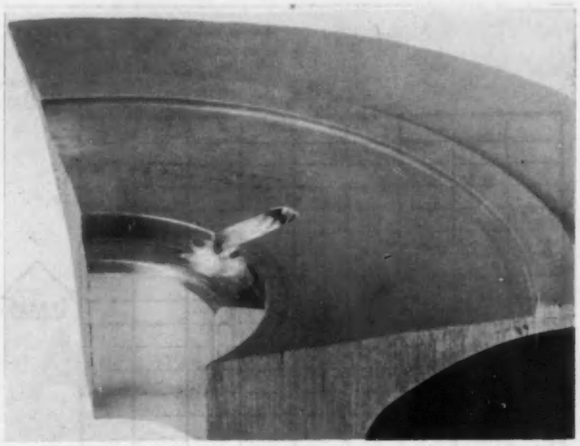


Fig. 5—Reworking to put radius on rotor drive slot reduced the stress concentration and induced a favorable residual compressive stress after final machining.

(Paper, "Experimental Stress Analysis in Small Turbines," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# Air Traffic Control by Computers . . .

**. . . is under extensive study by CAA and the military. There is real hope of transforming laborious manual functions into automatic operations.**

Based on paper by **Lee E. Warren,** Civil Aeronautics Administration

INVESTIGATION and tests are under way to determine the possibility of using stock model, business-type computers to perform air traffic control functions automatically.

A complete system will be developed out of the various equipments being tried. It will take all the information required from the pilot's flight plan and process it automatically so that from the time the plan is filed by the pilot until it appears on the display in front of the controller in any center through which the flight may pass, little or no manual handling will be needed. The equipment will print flight progress strips, or generate other types of information displays. It will also compute times over fixes automatically.

Looking still further into the future, computer techniques may be used to analyze the traffic situation, spot conflicts, and develop routine solutions, leaving the controller to concentrate on overall supervision of the operation and the handling of special types of operation.

Certain computers developed by the military are also under study and evaluation. One type can accept radar position data on a group of aircraft approaching an airport and generate heading information which will enable these aircraft to meet a precise schedule at the end of the runway at a higher landing rate than is possible with today's radar-assisted manual operations.

(Paper "A Forward Look at Air Traffic Control" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# 3 Problems

# Developing

# for

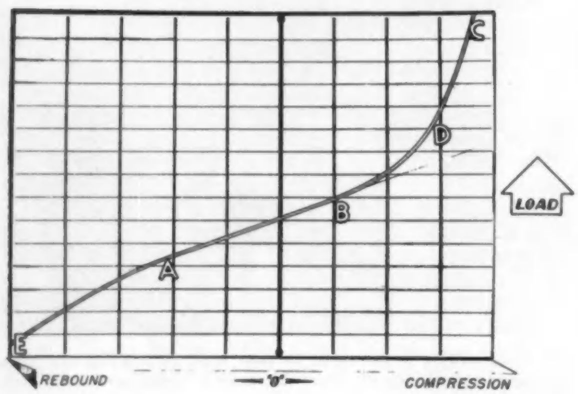



Fig. 1—Ideal load-deflection curve for air spring as determined by GM researchers.

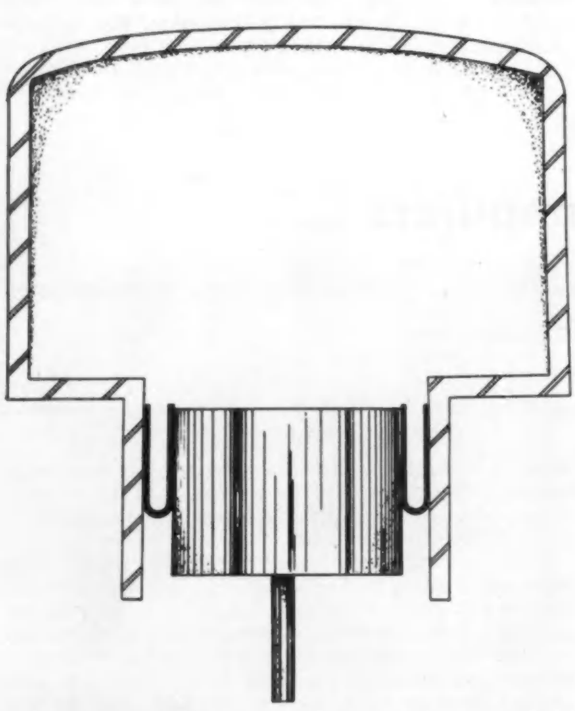


Fig. 2—Adding a rolling seal solved problems caused by size variations of the piston and cylinder, and friction.

AMONG the problems that were met in the development of an air spring for passenger-car application were:

1. Establishing the best shape for a load-deflection curve.

2. Obtaining an airtight seal without paying an excessive penalty.

3. Achieving the required gentle buildup and high end load of the load-deflection curve.

Best shape for a load deflection curve was first established—a needed reference point for specific decisions in development of the design for application to Cadillac's Eldorado Brougham. Fig. 1 shows that curve as determined by GM experimenters. Considering first A-B, the curve for a considerable distance on either side of normal position is a straight line, neither gaining nor losing rate. This characteristic, when coupled with some form of standing height adjustment, permits a consistently balanced ride over major road irregularities. Second, the spring should have (at C) a high end-load to reduce any sensation of "crash-through" over ruts and pot holes. Third, there should be a gradual blend (B-D) between the center (low rate) section and the high end rate (D-C) portion of the curve. Without a gentle transition, abrupt swells can upset an otherwise excellent ride. The last factor, while not a necessity, is very desirable. On rebound (at point E) a considerable reduction in load is worth seeking, both to reduce lift on braking and accelerating, and to prevent excessive input to the frame and suspension members. Of course, a gradual blend (A-E) should be provided.

GM designers bypassed the double-convolution bellows approach to passenger-car application, despite its proven success on GM buses. To appreciate

# and how they were met in . . .

# an Air Spring Passenger-Car Application

Based on paper by **V. D. Polhemus and L. J. Kehoe, Jr.,** Engineering Staff, General Motors Corp.

the problems involved in using the double convolution bellows in a passenger car, consider one used on the GM bus as a front suspension spring. It has an OD of 9 in. and has a stroke of 8 in. At normal height it would have a load carrying capacity of 2000 lb at 65 psi operating pressure and might be used as a passenger car front spring, if applied through a wish-bone linkage. However, obtaining the necessary 300 lb per in. spring rate would involve using an additional 700 cu in. reservoir.

For long-stroke direct acting rear axle applications, the picture becomes more critical. A reduction in diameter to bring loads to, let us say, 1200 lb at a 60 psi operating pressure means that the stroke has been reduced to an unsatisfactory amount. Dynamic stability is, as with a coil spring, a function of spring rate, spring length, and spring diameter. It is apparent that it would be difficult to obtain longer stroke by increasing the number of convolutions because instability would result, and could be overcome only by guiding the bellows in some fashion. Even assuming that these difficulties could be solved, the load-deflection curve does not have the shape previously determined to be the optimum.

Finding it hard to get 100% seal against air leakage without paying an excessive penalty (in cost for

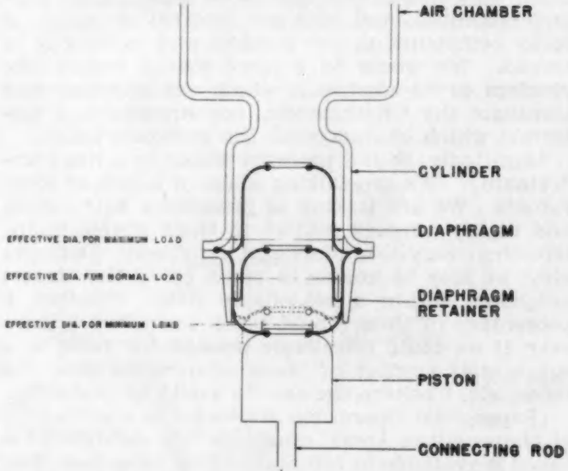



**Fig. 3—Variable area piston is achieved by change of effective diameter wth position.**

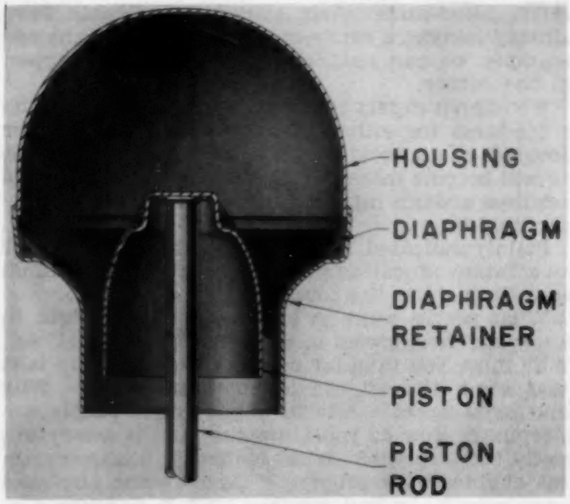



**Fig. 4—Final air spring design as developed by GM researchers.**

precision machining and in friction), GM designers increased the piston clearance and installed a rolling seal (Fig. 2). That eliminated two problems:

1. Minor size variations of the piston and cylinder.
2. Friction.

To get the required gentle buildup and high end load, the outside diameter of the diaphragm was increased, and the piston and retainer were adjusted to permit regulated adjustment of effective piston area (Fig. 3). This brought about the effect of a variable area piston.

The diaphragm is restrained between the piston and the outer skirt (diaphragm retainer), thus the effective diameter is fixed for some distance below and above the normal position. As can be seen from the upper piston position drawing, when the diaphragm is lifted up and out of its previously restrained stations, an increase in effective diameter (and hence an increase in effective working area) is obtained. Looking at the view of the piston in its lowest position, it can be seen how the diaphragm, lifting away from the piston, produces greatly reduced effective diameter. In all positions the length of a horizontal line, tangent to the meniscus, determines the effective diameter. Note the percentage increase, in effective area, in the full compression position is less than the decrease in full rebound. This is necessary because air pressure increase, as the piston enters the chamber, tends to assist in load buildup, while in rebound, the air pressure drop requires a more rapid reduction of effective piston area.

Fig. 4 shows the final result of the GM air spring development program. Steel bead rings are used to attach the diaphragm to the piston and retainer and a wedge-shaped rubber lip surrounds each ring. The internal air pressure on the rubber lips forms a seal similar to the tubeless tire and its rim. The diaphragm is installed in the retainer by temporarily deforming the normally circular outside bead into an oval shape that will pass up through the circular opening of the retainer.

(Paper "Cadillac's Suspension for the Eldorado Brougham"—Part I—Experimental Development of the Air Spring" on which this abridgment is based is available in multilith form together with Part II—Application of the Air Spring to the Production Design—from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# Airports' Neighbors . . .

**. . . are more tolerant of air traffic once they understand operating fundamentals of aircraft and terminals. What's needed is an educational campaign to develop this understanding.**

Based on paper by **Vice-Admiral Charles E. Rosendahl,** USN (Retired) Executive director,
National Air Transport Coordinating Committee

AIRCRAFT are going to create noise for the foreseeable future. And, although accidents have already become a rarity in terms of total flight operations, we can anticipate that they will happen in the future.

We cannot expect the airport neighbor to develop a fondness for either the noise we create or the prospect of an accident. But we have learned that he will become more tolerant of air traffic when he acquires enough information to permit him to understand it.

Plainly indicated, in our judgment, is the need for an aviation education program in every air terminal area throughout the country.

What people want to know and have a right to know are the answers to some very basic questions: Why must you take off over my home? Why is it that some aircraft are lower than others? Why must you operate late at night when people are sleeping? How do you know the pilot is competent to fly the airplane? What is done to make certain the engines work properly? Aren't some airplanes overloaded? In bad weather isn't it dangerous to take off and land?

By providing factual, easy-to-understand answers to these and many similar questions, we would remove that substantial shadow of doubt, fear, misunderstanding, and outright frustration which is today compounding our problem and causing it to spread. We would to a large extent reduce the problem to its essentials, which are physical, and eliminate the emotionalism, controversy, and distortion which characterizes the situation today.

Admittedly, such a program would be a huge undertaking. We are talking about millions of individuals. We are talking of presenting a technical and highly complex subject to these people in interesting, easy-to-understand language. Conceivably, we may be unable to reach all of the airport neighbors within a reasonable time. Possibly, a percentage of them would reject our effort. However, if we could effectively present the facts to a substantial number of those who reside near the terminals, I believe the results would be gratifying.

(Paper, "Air Operations Problems in the Vicinity of Metropolitan Areas" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# Cadillac's Air Spring for the Eldorado Brougham

Based on paper by **F. H. Cowin and S. L. Milliken,** Cadillac Motor Car Division, General Motors Corp.

ADAPTATION by Cadillac engineers of the GM Engineering Staff's basic air spring design to the Cadillac Eldorado Brougham brought many changes in detail. Among these were:

## 1. Mounting of the Air Spring in the Frame Front Cross Member

The original design of piston, diaphragm, and air dome (Fig. 1—left) resulted in an airdome too large for the space available in the Brougham cross member.

This led to a basic redesign of the piston (Fig. 1—right). It was made with a hollow shape and a 3 in. diameter hole at the top. The 126 cu. in. volume in the piston reduced the volume required in the dome by 36% This smaller-sized air dome fits into the space available in the cross member.

Mechanical retention to the diaphragm—needed to keep the piston from jumping out of position if the pressure were lost—was obtained by adding a narrow strap, or clip, that twists into the top opening of the piston, and extends over the inner bead of the diaphragm.

At the bottom of the piston, a stud was added, which bolts into the lower control arm tray. The head of this stud is encased in a phenolic resin cover that has a spherical shape to match the seat in the bottom of the piston.

A rubber "O" ring is held against the piston-seat depression by a stamped retainer. The "O" ring thus prevents the piston from pulling off the lower control arm at extreme rebound height.

## 2. Changes in Size of Diaphragms

The cord pattern, and resulting strength of the diaphragm, is satisfactory if the diameter of the inner bead is at least 30% of that of the outer bead. This influenced the proportions of the spring.

The production diaphragms have a section that allows enough rubber to insure good coverage of the cords. Wall thickness, however, is still thin enough

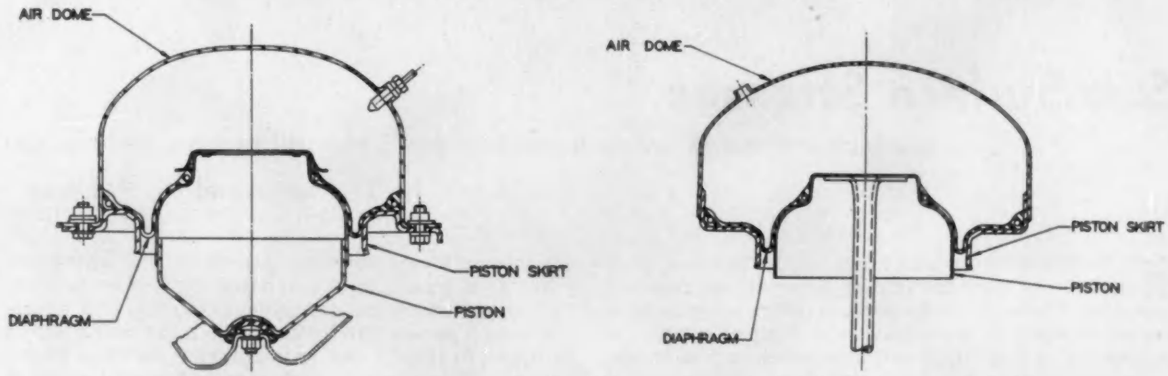



**Fig. 1—First design of Cadillac's air spring (left) and final production design (right) show numerous changes.**

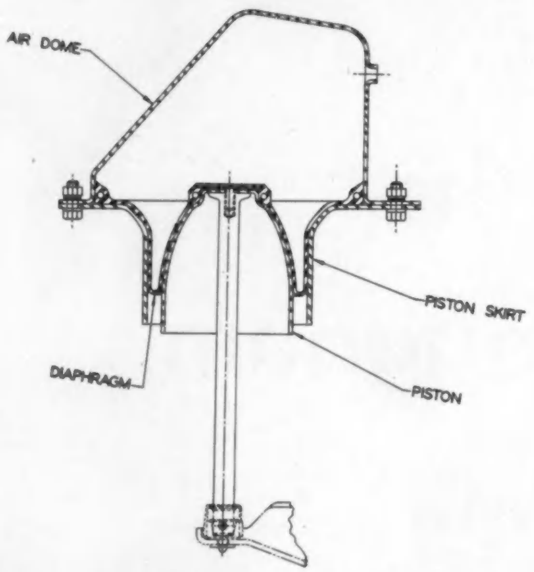



Fig. 2—Rear spring design for the Brougham. Piston diameter is smaller than front spring and the top is closed and has a bullet-nosed shape.

to insure low strain in the outer skin of the membrane during the stroke cycle. The cords are wrapped around the bead wire to avoid any exposed ends that would diffuse air.

At first, radial grooves were moulded into the diaphragm for venting during the moulding operations, but this sometimes exposed the cords and caused air leaks. A change to radial lands provided venting without exposure of the cords.

### 3. New Specifications to Insure Adequate Sealing

To maintain satisfactory air seal between the diaphragm bead and the dome and piston, many methods of finishing, plating, and sealing were investigated. This resulted in the following specification for the air domes and pistons:

- Use mill-run 1008 cold-rolled satin-finish steel with surface of 45 microinch maximum.
- After forming, buff the sealing areas to remove die marks.
- Apply a rust-preventative phosphate coat.
- Apply black primer paint to the same area.
- Cover sealing areas with silicone grease No. 4.

The diaphragms were changed from tapered bead seats to vertical bead seats allowing a normally-drawn sealing diameter in the air dome. This, along with the separate-piston-skirt construction and stiffer bead wire, allows a slightly oversize diameter on the diaphragm and a light interference at the seal.

### 4. Redesign for Rear Suspension

The parts for the air springs at the rear suspension are not interchangeable with those at the front. The piston (Fig. 2) is of smaller diameter, as dictated by the air pressure, spring position, and geometry for the four-link suspension. The top is closed and has a bullet-nosed shape. A rod is anchored in the piston and connects it to a bracket on the rear-axle housing.

The lower end of the rod is domed and bears in a steel cup that is attached to the axle bracket. The rod is loosely pinned to the cup to prevent its jumping out of position at any time.

A rubber seal around the cup and the rod retains the grease and insures long-life lubrication for the bearing.

The shape of the dome was determined by the volume required (300 cu in.) and the space available. The attachment to the piston skirt is the same as at the front spring.

The diaphragm is of the same type as the one used at the front spring, but is not interchangeable. The center of the rear diaphragm is solid and has a steel washer vulcanized in place. A stud on the under side of this washer screws into the tapped head of the piston to give a mechanical tie between the diaphragm and the piston.

(Paper, "Cadillac's Air Suspension for the Eldorado Brougham" Part II—Application of the Air Spring to the Production Design—on which this abridgment is based is available in multilith form together with Part I—Experimental Development of the Air Spring—from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# Sub-Surface Stresses . . .

## . . . must be corrected when measured by X-ray diffraction techniques.

Based on talk by **M. G. Moore and W. P. Evans**
Bradley University Caterpillar Tractor Co.

MEASUREMENT by x-ray diffraction has become a commonly used method of determining residual stresses. Stresses in sub-surface layers must be corrected before a true evaluation of their effect on the properties of materials and structures can be made.

Because x-rays are diffracted from surface layers only, a determination of residual stress in depth requires removal of material to the depths desired. As successive layers are stripped from the specimen, relaxation occurs in the exposed surface in proportion to the stress in the layers removed. All determinations except the initial value must be corrected in order to obtain the true internal stresses which existed. The stress in each removed layer is used to calculate the correction for the next layer. The procedure can be terminated at any desired depth

without completion of measurements to the center of the specimen.

The corrections are derived from Theory of Elasticity and utilize the equations of equilibrium and compatibility as a basis. Considerable simplification occurs, depending upon geometric shape and stress symmetry. Cylinders and flats were separately considered.

The principal stresses in a solid cylinder are shown in Fig. 1. Measured longitudinal ($\sigma_{zm}$) and tangential ($\sigma_{\theta m}$) stresses in an induction hardened steel bar are shown in Fig. 2. As is seen, no tensile stresses were measured whatsoever, which is a condition not possible in an equilibrium state before the layers were removed. The corrected stresses are shown in Fig. 3, including the calculated radial stress ($\sigma_r$). The originally measured stresses ($\sigma_m$) are included on the same graph for comparison.

Hypothetical measurements of stress and corrections are shown in Fig. 4 for a steel plate, which, except for the linearly assumed ($\sigma_m$), might exist as a result of deep hardening on one side only. Marked deviation between the apparent and actual stresses can be seen.

The corrections become increasingly important as more metal is removed, and the stress in removed layers is high. The thickness of the removed layers is governed by the rate of change of the stress. High stress gradients require thin layers. Enough cuts must be taken to show changes of stress in transition zones, because the calculations will not supply deviations missed in the original measurements.

(This abridgment is based on a talk given to Division IV, Residual Stresses of the Iron and Steel Technical Committee.)

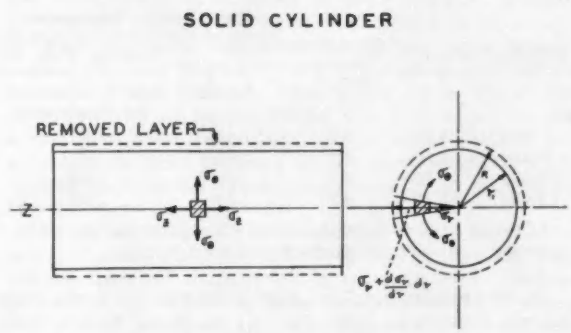



Fig. 1—Principal stresses in solid cylinder

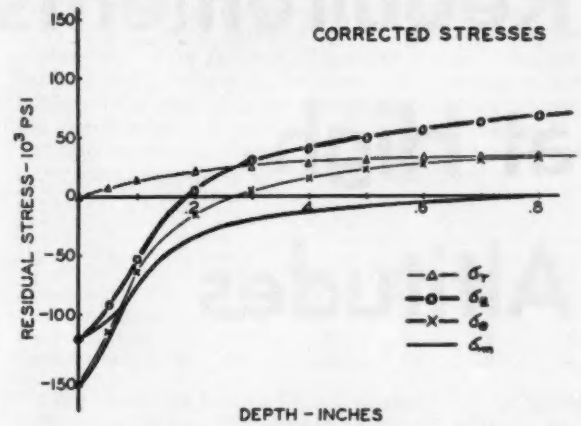



Fig. 3—Corrected stresses including the calculated radial stress

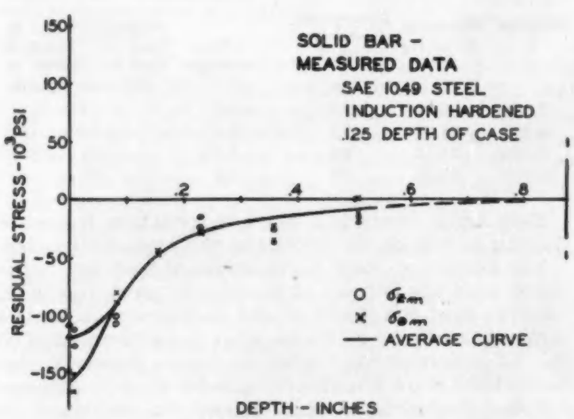



Fig. 2—Measured longitudinal and tangential stresses in induction hardened steel bar

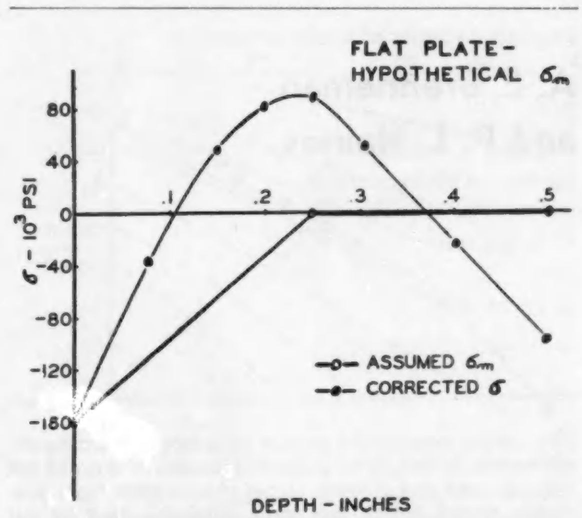



Fig. 4—Hypothetical measurements of stress and corrections for a steel plate, which except for the linearly assumed ($\sigma_m$), might result from deep hardening on one side only.

# Passenger Car Octane Requirements at High Altitudes

Based on paper by

**A. E. Brenneman and P. L. Haines,**

Esso Research and Engineering Co.

**This article expands the present knowledge of octane requirements at altitude by presenting passenger-car road test data obtained over altitude ranges greater than those previously tested. Survey type data, applicable to total car populations both resident at high altitudes and transient from higher to lower altitudes, are also given.**

**Current road test results on cars driven from one elevation to another are in good agreement with published road test data and single-cylinder engine tests performed in an altitude chamber up to the equivalent of about 4000–5000 ft. For this type of driving at higher altitudes, current tests show a greater drop in octane-number requirement than published data would indicate.**

Tests involving the greatest spread in altitude were conducted in Peru. Four cars were driven east from Lima over the continental divide. Octane requirements were determined at four points where suitable test courses were available and no engine adjustments were made during the progress of these tests. Pertinent results are shown in the following table. (Note that the deviations from the Bureau of Standards' results are quite pronounced at very high altitudes.)

**Peru Tests**

| Elevation, ft | Barometer, in. of Hg | Atmospheric Temperature, F | Octane-Number Requirement: 4-Car Average | Octane-Number Requirement: Predicted from Bureau of Standards' Data for Similar Initial Requirement |
|---|---|---|---|---|
| 600 | 29.23 | 59 | 82 | 82 |
| 6,500 | 23.58 | 62 | 57.5 | 61 |
| 10,000 | 20.70 | 51 | 41 | 48 |
| 13,400 | 18.27 | 45 | 14[a] | 30 |

[a] One of the cars operated at this altitude on normal heptane (zero octane number) without knock.

In Venezuela similar tests were run in three cars at sea level and 3000 ft. As in Peru, there were no intervening engine adjustments. These results showed good agreement with the Bureau of Standards' work up to the 3000-ft level.

In Billings, Mont., three cars were driven from an elevation of 3300 ft to an elevation of 10,800 ft. Octane-number requirements were determined at four locations with the following results:

**United States Tests**

| Elevation, ft | Barometer, in. of Hg | Atmospheric Temperature, F | Octane-Number Requirement: 3-Car Average | Octane-Number Requirement: Predicted from Bureau of Standards' Data for Similar Initial Requirement |
|---|---|---|---|---|
| 3,300 | 26.45 | 85 | 73 | 73 |
| 5,000 | 24.62 | 76 | 66.5 | 66.5 |
| 6,500 | 23.55 | 69 | 59.5 | 61 |
| 10,800 | 20.63 | 65 | 40 | 46 |

Here again there is a marked deviation from the Bureau of Standards' results at the higher altitudes.

The results of these three series of tests are compared with the Bureau of Standards' work in Fig. 1. Observe that the slopes of the curves are about the same at the lower altitudes, that is up to about 5000 ft. At progressively higher altitudes, however, the latest tests show a markedly greater drop in octane-number requirement than would be predicted on the basis of Bureau of Standards' data. Differences in atmospheric temperature could account for some of this deviation, but, based on the findings of other investigators, it is very unlikely that temperature differences could account for much of the deviation.

From the consistency of the deviations, it would appear that they are significant; but the reasons for the deviations were not investigated nor are they apparent.

The procedure employed in these tests is similar to that used by other investigators. It consists simply of obtaining the octane-number requirement by the Uniontown method on one or more individual test cars driven from one altitude to another without intervening adjustments. Primary reference fuels are employed. Humidity data are not included since in all cases differences in humidity were so small that they would account for less than one octane number in requirement. Atmospheric temperatures on the other hand are reported, since in some cases this information may help explain the results obtained.

The cars selected for these tests were, in each case, standard American models, none of which were over three years old at the time.

**The statistical antiknock requirement of the total car populations resident at various altitudes are not necessarily established by this standard relationship between altitude and octane-number requirement.**

**For total car populations more or less isolated at higher altitudes there appears to be a trend for spark timing to be advanced. In this way the car owner can take advantage of the lower octane requirements, but this does lessen the anticipated effect of altitude on octane requirement as judged by test car results.**

**When total car populations have easy access to several altitudes, the trend in spark timing and octane-number requirement appears to be determined by the lowest altitude frequented. (This assumes that the same quality of gasoline is marketed at all locations.)**

Two octane requirement surveys were conducted in Venezuela, one at Caracas (3000 ft) and the other at Maracaibo (approximately sea level). About 100 cars were used at each location and the selections by make and age were substantially the same. No individual cars were common to both surveys and both areas had the same quality of commercially available fuels. In addition, it was found that—despite the difference in altitude—the spark advance settings of the two groups of cars were essentially the same.

Results from later surveys made in more isolated mountain communities have led to the thought that this similarity in spark timing may be attributed to the ease and frequency with which Caracas drivers descend to sea level, and probably reflect a tendency for spark timing to be set to provide acceptable knock performance at the lower altitude.

It might be expected that, if the Bureau of Standards' relationship were to hold, there would be no significant difference in requirement for the two Venezuelan locations, other than that due to altitude alone. This was so for these particular tests. This good correlation gives confidence for using the survey type of comparison in studying the effect of altitude.

Requirement surveys were also conducted near cities at three different altitudes in Colombia and for cities at two altitudes in Brazil. As in the Venezuela surveys, the car populations were roughly equivalent within each country, but differed somewhat from country to country. In these tests, however, the difference between sea-level and altitude requirements were less than would be predicted from the Bureau of Standards' work, as illustrated in the following table:

| Cars Satisfied, % | Colombia Surveys | | | | Brazil Surveys | |
|---|---|---|---|---|---|---|
| | Difference in Reference Fuel Octane Requirement | | | | | |
| | Sea Level to 5000 Ft | | Sea Level to 8600 Ft | | Sea Level to 2600 Ft | |
| | Barranquilla to Medellin | Bureau of Standards | Barranquilla to Bogota | Bureau of Standards | Rio to Sao Paulo | Bureau of Standards |
| 20 | 5 | 20 | 24 | 33 | 6 | 10 |
| 40 | 4 | 18 | 23 | 29 | 4 | 9 |
| 60 | 4 | 16 | 16 | 27 | 4 | 8 |
| 80 | 3 | 14 | 16 | 24 | 3 | 7 |
| 90 | 3 | 12 | 7 | 20 | 3 | 5 |

On considering the deviations of survey data in Colombia and Brazil from Bureau of Standards' figures, the only apparent major variable was spark timing. Some car owners may have had leaner altitude jets in their carburetors but this was not investigated. The factors of humidity and temperature tended to offset each other. The average spark timing data obtained are summarized in the following table where it will be noted that, unlike the Venezuela results, there is a definite trend toward more advanced spark timing with altitude:

| | Colombia | | | Brazil | |
|---|---|---|---|---|---|
| | Barranquilla | Medellin | Bogota | Rio de Janiero | Sao Paulo |
| Altitude, ft | 0 | 5000 | 8600 | 0 | 2600 |
| Cars Retarded, % | 49 | 40 | 43 | 37 | 35 |
| Cars Standard, % | 38 | 24 | 13 | 40 | 17 |
| Cars Advanced, % | 13 | 36 | 44 | 23 | 48 |

There appears to be a logical explanation for these differences when the geographical conditions and driving habits of the people are known. In the loca-

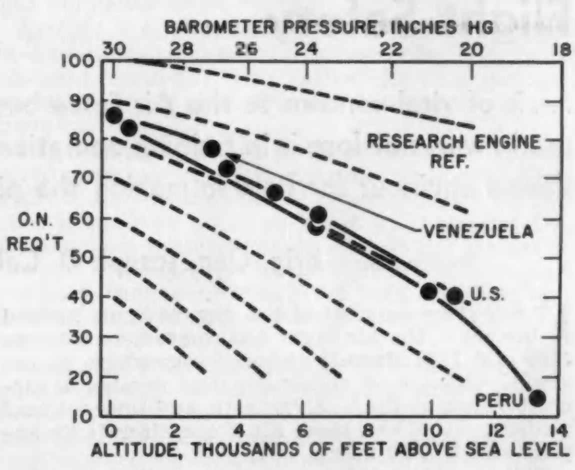



**Fig. 1—At altitudes up to 5000 ft, tests performed in Peru, Venezuela, and the United States closely agree with the Bureau of Standards research work on octane-number requirement. Above 5000 ft, however, the latest tests indicate lower octane-number requirements than the Bureau of Standards' data.**

tions which show an increase of spark timing with altitude, the particular cities are on plateaus more or less isolated from other areas either by distance or intervening terrain. Thus, in these somewhat isolated high-altitude cities, spark settings are adjusted to compensate in part for the less dense air.

In the case of Sao Paulo, travel to the sea coast requires about 75 min over relatively flat country with a sharp drop in altitude at the end of the trip. The density of traffic is negligible compared to that encountered between Caracas and sea level. Consequently, most people operate almost entirely at the altitude requirements of Sao Paulo.

An interesting situation developed in the Bogota octane-number requirement survey, shown in Fig. 2

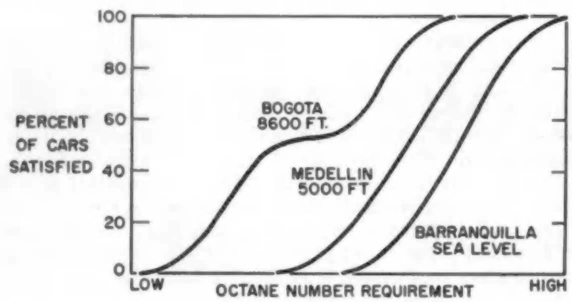



Fig. 2—Passenger-car octane-number requirements as determined by surveys in Colombia. The cause of the plateau-type curve for Bogota points strongly to the existence of two separate groups: one a high-requirement group of resident cars which seldom leave the Bogota Sabana, and the other a low-requirement group of cars which frequently leave the Sabana for lower levels and which have had the spark retarded to lessen knock at lower altitudes.

together with other Colombia survey results for comparison. Bogota is situated at 8600 ft near the border of an almost flat plateau of some 50,000 sq miles of area, called the "Sabana."

Note that the Bogota curve is not the typical "S" curve normally obtained in this type of survey. Instead, the curve shows a definite plateau. When this was encountered at the completion of the survey a followup personal contact was made of most of the car owners involved to determine the cause. The evidence gathered points strongly to the existence of two separate groups: one a high-requirement group of resident cars which seldom, if ever, leave the Bogota Sabana, and the other a low-requirement group, composed of what might be considered transient cars which frequently leave the Sabana for lower levels and hence have had the spark retarded to lessen knock at lower altitudes.

This second series of tests was performed using the road octane requirement survey technique. This type of survey is a statistical analysis of car requirement results obtained from a sample of about 100 cars selected according to make and age to represent the total car population of the particular area being studied. The requirement of each car is determined by the Uniontown method in the as-received condition. The results may be expressed as per cent of cars satisfied as a function of the primary reference fuel octane number. By comparing results of surveys at different locations, it is possible to select comparable data to show the effect of altitude.

(Paper, "The Octane Requirement of Passenger Cars at High Altitudes" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# Flight Safety . . .

**. . . is of vital concern to the Air Force because it must conserve combat potential for use in war—not lose it in training operations during peace. The Air Force looks to the design engineer for help in making the pilot's job simpler, surer, and therefore safer.**

Based on paper by **Brig.-Gen. Joseph D. Caldara,** USAF, Director of Flight Safety Research, Norton Air Force Base

AT any given moment of the day, 24 hours around the clock, the Air Force has somewhere between 1100 and 1200 aircraft airborne somewhere in the world. This almost equals the total number of aircraft owned by the U. S. domestic and international airlines. In 60 sec, these Air Force aircraft fly approximately 4750 miles.

This sort of operation over the past five years has resulted in some 4000–5000 fatalities, of which over 2000 were pilots. This is a terrific combat potential which has been lost.

The major-accident trend in the Air Force has been generally downward. Back in 1921, we had 506 major accidents per 100,000 hr of flying. In the last 36 years, that accident rate has declined until today it is down to 15 major accidents per 100,000 hr. This is an all-time low, but *it is not low enough.* The decrease in the frequency of major accidents has been accompanied by a decrease in fatal accidents. However, here is a serious paradox: 25 years ago the Air Corps had 1 fatal accident for every 13 major accidents; today we have 1 fatal accident for every 5 major accidents. This means that while we have reduced the frequency of major accidents, the chances of the pilot being killed in one have tripled.

Another way to portray the improvement of ac-

cident prevention efforts is to compare our accidents to hours flown. Back in 1922, the Air Corps averaged 1 major accident per every 198 flying hours. By 1950 the Air Force was flying 2741 hr per major accident, and by 1956 this had increased to 6730 hr per major accident. Again, though, we have this grim corollary to such a happy thought. In 1930 8% of all major accidents were fatal. Today over 21% of all major accidents are fatal.

This reduction in accident rates has been attained in spite of the fact that the operational performance of USAF aircraft has increased in every dimension. Aircraft go higher, faster, and farther than ever before, with prospects of an increase in all of these parameters in the immediate forseeable future.

During the past several years, it has become apparent that in terms of cause factors, human error is of critical importance. Almost half (47%) of all accidents are consistently charged to "pilot error." Another 10% are charged to other human errors, and a large proportion of the undetermined accidents imply some type of human error. Taken collectively, the human contribution to accidents exceeds all other primary causes by a ratio of almost 2 to 1. Further critical examination of these accidents indicates, however, that this human error is not necessarily the result of negligence or willful violations on the part of the human involved, but could be the direct result of a situation which forces the human to perform in a situation which demands more than his design limitations are capable of responding to.

A typical example of the limitations inherent in the perception-decision-response sequence is found in the decision which must be made in order to avoid a collision between high-performance aircraft. In the process of seeing, when a light wave reaches the eye, the wave is transmitted to the appropriate portion of the brain in the form of a nerve impulse which travels at a definite, measurable speed. The transmission time for the perceptional lag involved in this transmission will vary from 30 millisec to 3/10 sec, depending on conditions. If 1/10 sec is considered as average, this means that during this period of time, an object traveling in space at 600 mph has traveled 88 ft in 1/10 sec. Thus, its location is misperceived by this amount.

If two aircraft were on a head-on collision course, this distance would be doubled, which means that from the standpoint of either of the two pilots flying a head-on collision course at a rate of closure of 1200 mph, the position in space of the other aircraft would be 176 ft from its perceived position.

This time lag, however, is only the first and in many ways the least significant of those involved in a complete human perception-decision-response sequence. Once an object is perceived, the eyes must be refocused and the object thoroughly defined. This leads to recognition, and this may require as much as 0.5 sec. On the basis of recognition, a decision must be accomplished. For purpose of discussion, 1 sec will be assumed for this important step, although it is readily apparent that this is a bare minimum.

Response must then be initiated by the human, and the machine must then respond to the controls and deviate from a flight path by an amount sufficient to avoid collision. The time lag in the response of the controls and the time required for the aircraft to deviate from a given flight path, once the two controls are actuated, will require an absolute minimum of 2.0 sec. Thus, if two aircraft were on a collision course at 600 mph, 4 sec before a point of collision they would be 1 1/3 miles apart. If excessive time, in fractions of a second, were taken in any of these steps, a collision would be unavoidable.

When it is considered that the distance at which a fighter, for example, can be perceived in a head-on course is limited, the importance of these human design limitations becomes apparent.

There appears to be considerable truth in a current theory that at altitude, the eye focuses some 3 miles ahead of the wind-screen. We have in our records actual cases of formations of aircraft flying through each other under conditions of maximum visibility without any of the pilots involved ever being aware of the proximity of the other aircraft.

The Directorate of Flight Safety Research has emphasized the requirement for an anti-collision device for some time. During 1956 the USAF experienced 58 mid-air collision accidents. Of these 33 were fatal accidents resulting in 61 fatalities. Over half of the accidents were fatal—and in every one of these fatal accidents, an average of about two people were killed. The days of "see and be seen" in flying are at an end.

Another type of perceptual error is related to the difficulties which the pilot has in interpreting the cues available to him during the landing phase. This is demonstrated by the fact that the landing phase is the most critical of all phases of flight. Approximately 45% of all accidents occur at this time. Over a two-year period, over 2000 landing accidents occurred during non-emergency conditions. Incidentally, we average 3 major accidents for every minor accident in this landing phase category. In over 97% of the times, these accidents occurred under good weather conditions, and the vast majority of them occurred during daylight hours. To be more specific, in 313 instances, the pilot undershot and 135 instances he overshot the runway.

In most cases, these accidents were directly attributed to difficulty in making proper distance-rate of closure judgments. This faulty judgment is more prevalent under good flying or landing conditions than bad.

Regardless of weather, we do much better landing our aircraft using ground-controlled approach. This again illustrates the need of mechanical aid for the pilot if he is to accomplish his task successfully. Although the performance of aircraft has increased two and three-fold during the past two decades, the auxiliary equipment which the pilot uses has not received a comparable amount of engineering attention.

Continued reduction in Air Force accidents is to a great extent the direct responsibility of the design engineer. With such help, we can accomplish the mission of the Directorate of Flight Safety Research —to conserve the combat capability of the Air Force for use in war.

(Paper "Engineering Design for Human Limitations" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

## Here's a rundown of present passenger-car, truck, and off-highway

# tire TRENDS and predictions of . . .

## Passenger-Car Tires

**TREND** PASSENGER-car design has changed gradually over the years with the trend moving toward larger sections, lower pressures, and smaller rim diameters. Rayon and nylon cords have replaced cotton, and synthetics have replaced most natural rubber. Now, almost all new passenger-car tires are of the tubeless type.

Many of the 1957 cars are using the latest smaller-diameter tires. Load ratings are comparable but the tires have larger cross-sections, 2 psi lower inflation, and use 14 in. diameter rims. The smaller tire diameter permits smaller wheel housings which, in turn, allow the car designer to lower overall car height and provide more usable passenger space—probably the primary reasons behind the trend toward smaller tires.

**FUTURE** SINCE tire changes are prompted considerably by car design, it is necessary to predict future car design before we can intelligently predict what the future will hold for tires. Future car changes will probably be in the direction of:

1. Lower overall height.
2. Elimination of the spare tire.
3. Greater sustained speeds.
4. Greater acceleration.
5. Quieter operation.
6. Lighter weight.
7. Air springs replacing leaf and coil springs.

Of course, there will be other changes, but these are the ones which are expected to have the greatest influence on tires.

Lower overall car height indicates that we may have still smaller tires. The problem here is the brake. Unless an effective small-diameter brake can be designed, the low-profile tire may provide the only solution to lower car height. Since a low-profile tire will probably ride harder and have less durability than today's tires, the tire manufacturers will be faced with a major redesign job if they're going to satisfy the demands of the customer.

Another problem associated with lower car height is illustrated by the new 14 in. tires. These tires have already used up most of the clearance available between the brake drum and the rim. To get greater clearances we'll have to consider such possibilities as:

1. Thinner rims, with lower flanges and shallower well depth.
2. Removable-flange rims, with no well.
3. Some type of integral tire and rim.

Also tied in with lower overall height is the possible elimination of the spare tire. Now the rear-deck height is limited by the spare's diameter. So long as the spare tire is positioned vertically, as at present, the overall deck height cannot be further reduced, except as the tire diameter is reduced.

Even though the spare tire may be eliminated, there is likely to be something to take its place, at least for an interim period. One possibility being considered is a collapsible 2-ply tire which can be folded up and which uses a carbon dioxide bottle for inflation.

A second approach to the spare-tire problem would be an integral unit fitting in each of the four wheel positions. Here, a 2-ply tube within the tire would provide a reserve air chamber. Two valves would be required, one for the inner "spare" tire and another for the outer regular tire.

A third possibility would be a small solid or pneumatic tire which would bolt alongside the regular tire, requiring nothing to be removed in the case of a flat. Each of these possible spare substitutes has its own advantages and disadvantages and there may be other better solutions suggested before any one is actually adopted.

Making tires to withstand greater sustained car speeds and acceleration may mean special-type tires in which some characteristics are compromised for others. A high percentage of the tire industry's development facilities are already directed toward this problem and the manufacturers are confident that they will be able to supply whatever is needed.

Quieter tire operation has already made considerable progress. Tires have been designed to prevent the build-up of any one frequency. The causes of cornering squeal have been isolated and largely reduced. Research will continue to advance along these lines. Of course, the automobile manufacturers still have their problem of mechanical and wind noise which effectively masks running noise at the higher speeds. Until they can combine their remedies with acceptable styling, present tire noise level is not likely to be objectionable.

Lighter-weight cars will call for less unsprung weight in the tires and the wheels in order to pro-

Based on paper by **R. P. Powers,** Firestone Tire and Rubber Co.

# ... What the FUTURE Holds for Tires

vide a good degree of ride. This will be accomplished with many of the features which permit higher speeds and by the use of simplified rims.

There is a possibility that air springs may replace leaf and coil springs on many cars. If this should happen, and if they are as good as we're told they are, then it is possible that tires will have less effect on overall ride than they do on present cars. If all this is true, then it is likely that we may see some reduction in tire sizes, particularly in cross-section, and some increase in inflation. However, this is one of those changes which would not necessarily follow any previous trend and hence is purely a supposition—we'll have to wait and see.

## Truck Tires

**TREND** Truck tires have always been designed primarily as load-carriers. The record indicates successively larger tires with some periods of lower inflation. Obviously, there is a limit to size because of the 96 in. overall-width limitation, a restriction which is likely to be permanent. In addition, the new superhighway bill calls for maximum axle loads of 18,000 lb, which means that there may be less usage of the larger sizes unless they can be justified on a cost-per-mile basis.

Insofar as tire and rim construction is concerned, the most radical change since the introduction of the pneumatic tire has been the recent tubeless program, radical not because of the tubeless feature, but because of the new type of rim and tire bead. Fig. 1 shows the rim and bead of a tubeless tire on the right as compared with the rim and bead of the conventional tire on the left. Here, a multipiece high-flange rim is replaced with a simple one-piece drop-center rim with relatively low flanges.

One definite trend in truck tire design is toward greater traction. A more broken-up tread pattern with molded slits has been found effective. But, the trick here is to work out a design which does not sacrifice wear or resistance to wiping, and this is not an easy job. Wire coils molded into the tread have also been helpful in some special operations.

**FUTURE** AS with passenger cars, truck and trailer design is expected to make greater demands on tires than has been true in the past. Future truck changes will probably be in the direction of:

1. Lighter weight.
2. Higher sustained speeds.
3. More torque to drive wheels.
4. Lower trailer-bed height.
5. Quieter operation.

Because of axle load restrictions and competition, more actual payload with less vehicle curb weight may become a requirement for staying in business. The new drop-center rim tubeless-truck-tire program, however, is a significant step toward weight saving, amounting to as much is 40 lb per wheel position. We believe that the simplicity of this tire and rim assembly opens the door to still further weight reductions, possibly through material substitution, better design, and specialized constructions.

Higher sustained speeds are inevitable. The increase in horsepower is not limited to passenger cars. This factor, along with the modern type of road with gentle slopes and few curves, can only mean that truck tires, just like passenger car tires, must operate successfully under higher sustained speeds. This type of service may call for specialized tires. In any event, many of the features which will make cooler running passenger-car tires will have similar effects on truck tires.

More torque to the drive wheels of a truck adds up to faster tread wear. The difference in wear between free-rolling wheels and drive wheels is quite significant. We expect this difference to become even greater, posing a tread wear problem similar to that with passenger tires. This additional torque may also result in slippage tendencies, calling for higher coefficients of traction between the tire and road surface.

Lower trailer-bed height (in order to obtain more box capacity) means either smaller-diameter tires or less spring travel. It appears that the demand will be for the smaller-diameter tires with, of course, no sacrifice in load capacity and certainly no reduction in brake size. Once again, the tire will be caught in a squeeze between overall height and nonshrinkable brake drums. One solution would be a tire section with some degree of low profile, such as with the passenger-car tires.

To mention quieter operation may be premature. In fact, the trend at the moment seems to be the

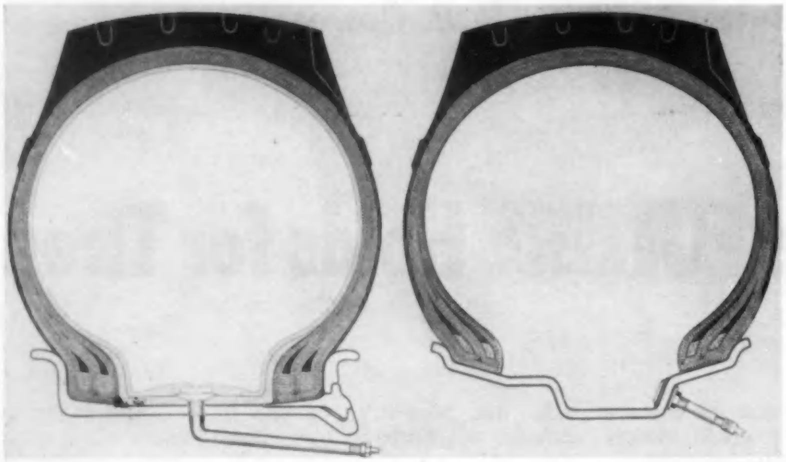


Fig. 1—The new tubeless truck tires feature a simple one-piece drop-center rim with relatively low flanges (right.) This replaces the multi-piece high flange rim of the conventional tire (left).

other way. However, with home building extending to the country along well-travelled roads we foresee that in time there may be a demand for less noise from trucks. Many of the same principles which are effective in reducing passenger-car tire noise also apply to truck tires.

## Off-Highway Tires

**TREND** In 1934 the first tires built specifically for off-the-highway service were introduced. Many of those same sizes (with different name sizes) are still in existence, with the trend in the past 20 yr being toward larger sizes. It would appear, however, that we are close to the maximum which can be economically built and shipped, the 48 × 68 size. This tire is 10 ft in overall diameter with a 4-ft cross-section. It is a low-profile tire and has been tubeless from the start.

This low-profile principle is the most recent major innovation among off-the-highway tires. In 1955, an almost complete line, called wide-base tires, was introduced. They provide increased load capacity with no increase in diameter and operate at lower inflation for a given load, thus providing some increase in mobility.

Rims, and the tire beads which fit on the rims, have remained basically unchanged since the first off-the-highway tires were built, except for the move to a 5 deg taper on both the base of the bead and the rim. This provides a tighter fit on the rim, reduces slippage, and lengthens bead life. These rims present a problem however, requiring special heavy tools for dismounting.

Probably the most outstanding trend with off-the-highway tires has been that toward diversification and specialization. Emphasis was first on traction, more recently on durability. Now we have floatation-type tires for sand, maximum-traction tires for soft-going, combination tires for on- and off-the-highway use, less aggressive tread patterns for trailer service, and perhaps the most important, those tires specifically built for greatest durability in rough and rocky service.

**FUTURE** Modifications in earthmoving vehicles will, of course, be more gradual than those in passenger cars and trucks. Nevertheless, changes can be expected and the major ones ahead of us are likely to be the following:

1. Use of larger vehicles.
2. Greater speed.
3. More torque to drive wheels.
4. All-wheel drive.

Larger vehicles can only mean larger tires. In off-the-highway service, mobility is sacrificed when duals are used; the only solution is larger single tires. Since most of the required sizes are already in existence, this change will have little effect except in number.

Greater speed, a result of more horsepower, has been a gradual trend. Higher speeds call for thinner, lighter-weight tires—a combination almost opposite to what the trend is at present. General durability, such as more wear and resistance to cutting and bruising, with less stress on tractive ability, has been the guiding design factor. Special tires for the higher-speed service may offer the best compromise, illustrating still more diversification in these off-the-highway tires.

When more torque is delivered to the drive wheels, there will be more slippage, scuffing, tearing, and wear. Tougher, more abrasive-resistant treads will help; but, actually, this condition is one which must be balanced with a more adequate tire size or more even distribution of torque, perhaps to trailer wheels.

When an all-wheel drive is substituted for free-rolling wheels, the overall tractive effort is increased by the elimination of the rolling resistance and by whatever tractive effort is developed in the trailer wheels themselves. This may amount to as much as 50% or more tractive effort, depending upon the terrain.

More driving wheels will ultimately result in more traction-type tires, but not necessarily new types.

(Paper, "Tires and Horsepower," on which this abridgment is based, is available in full, in multilith form from SAE Special Publications, 485 Lexington Avenue, New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# Airborne Electronics Faces New Problems

Based on secretary's report by **R. H. Beeson,** North American Aviation, Inc.

PROGRESSION through subsonic, supersonic, and transthermal speed ranges means that electronic equipment will have to accomplish the functions of sensing, transferring information, computing, and others, with greater precision, accuracy, and rapidity. It will, at the same time, have to be made more powerful, compact, and lighter.

Electronic equipment also will have to stand wider temperature variations, greater pressure changes, and vibrations which will move to acoustic frequencies. Its reliability will become of ever greater importance in order to keep maintenance at a minimum because the system's increasing complexity will require a man with an I.Q. of 150 to troubleshoot and repair it.

The speed of electronic vibrations is approximately Mach 100,000, yet the equipment manufacturers still have a problem in harnessing this speed to the degree necessitated by the ever-increasing speed of aerodynamic devices. Aircraft speeds are diminishing the effectiveness of the human eye by reducing the size of the peep holes for cockpit windows, and the effectiveness of the human mind by reducing the time for mental and physical reactions. This makes it imperative to have complete ground control of aircraft flight at terminal areas, and a small proximity warning device outside terminal areas to prevent collision.

These air traffic and navigational systems will require high definition communications systems. Communications will be converted into digital information and transmitted back and forth between the aircraft and the ground, and inverted into computers in the aircraft and on the ground to determine actions to be taken automatically by the airplane.

Manufacturers are trying to increase reliability and develop simple testing methods to ease the problem of maintenance. Reliability is obtained by better circuitry, improved components, and more positive quality control. Effective automatic testing will be available but care must be exercised lest the equipment become so complex that geniuses will be needed to maintain it.

**Q.** What is being done to make electronic systems easier to maintain?

**A.** Smaller subassembly, throw-away packages are being used, but it remains to be decided how far to go in this direction. Test equipment is being broken down into simpler units.

**Q.** What is being done about the reliability of vacuum tubes?

**A.** Aging, ruggedizing, increasing temperature capabilities, and in some cases substituting transistors in certain circuits all tend to eliminate tube failures. The so-called shake, rattle, and roll testing of tubes is worth while and picks up 97% of the tubes that would have failed in the first 60 days of operation. Elimination of tube heaters is being studied for use in temperatures of 500 F or more.

**Q.** Are electronics manufacturers making aircraft traffic control equipment?

**A.** Yes, a good many companies are making these devices. However, the CAA and military authorities are trying to decide on a mutually advantageous system.

**Q.** Is anything being done about creating capsules which might perform dual functions and so eliminate some duplication of airborne equipment?

**A.** This is a problem requiring the coordination

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Douglas Aircraft Co.

**D. C. Bright**
Radio Corp. of America

**L. N. Welsch**
Boeing Airplane Co.

of manufacturers of aircraft and equipment. Quite a bit has been done with satisfactory results. The use of capsulated subsystems, such as power supplies and amplifiers, in which the components may perform the same functions for two or three other subsystems, has reduced wiring, eliminated controls, and reduced both testing time and probability of failure.

**Q.** What is the result in running time on airborne equipment prior to installation in the aircraft?

**A.** It is felt that by bringing out the weak points in much of the electronic equipment, such running time actually increases the life expectancy of the electronic portion of such equipment. However, there is a point at which wearing of the mechanical portions of the equipment begins to shorten the life expectancy of the entire system. Equipment manufacturers run-in equipment from 50 to 500 hr, depending on its character.

**Q.** Is electro-mechanical reliability being designed into the equipment?

**A.** It is very hard to find electro-mechanical designers, however, the industry is working on this problem. Improvement may not be evident in the end article for some time to come.

## The Weapon System

The weapon system concept requires a great deal of coordination between the prime contractors of airborne equipment and the airframe manufacturer, who generally has the responsibility for the entire system. Electronic systems built by several different suppliers must be integrated into one complete system which will operate to give the desired end function of the weapon system.

Complete compatibility is required between different systems and subsystems. To attain this end it is often advisable for the airframe manufacturer to assign technical people to work with the equipment manufacturer to help solve these problems. The equipment manufacturer benefits because it helps him to understand the environment in which his equipment must operate, and it allows for design changes which take these factors into consideration.

In some instances, contracts have been written which allow responsibility for integration to be given to an equipment manufacturer. In such a case the integration is accomplished before the airframe manufacturer receives the equipment. Equipment manufacturers, in general, feel this gives them an opportunity to control their product better until it is ready for actual installation.

It is a problem to know how much bench testing to do and when to stop testing a complex integrated system. Many times a system is tested, adjusted, and tinkered with until it is operationally inferior to the condition in which it was received. The best solution is to receive a system, turn it on, give it a single basic problem to solve, and get it turned off as fast as possible. The time to do the big testing job is after it has been installed in the airplane and prior to flight.

**Q.** Just what is the definition of a weapon system?

**A.** It is a machine and associated equipment, capable of performing a definite mission or series of missions, including the vehicle itself, its cargo, runways or launching facilities, maintenance procedures, tools and equipment, and storage facilities, which may be delivered to the Armed Services as a completely developed, tested, and operable system.

**Q.** Is the weapon system concept any good? Can it be made to work to advantage, or is it too complex and cumbersome to be practical?

**A.** As long as we have the requirement for the type of weapons we are now manufacturing, somebody has to coordinate the system. Many improvements can and will be made in the coordinating procedures. The concept is still young and, as more people get into the act, new and better methods of control will be devised.

**Q.** Is it possible that some means other than the complex system of electronic black boxes and integration of systems could be used to accomplish the same end?

**A.** As long as the Armed Services require performance and accuracies of such close tolerance, we know of no other way of accomplishing the mission than by the complicated systems we now use. The Armed Services generally require a second source for articles, which allows for development of a different approach to the problem, and, while many minor variations exist, the major problems are still solved by the same general methods.

**Q.** Have we reached the ultimate in complexity, or are there more complex systems in the future? If so, how far can we go, or is there an end to man's ability to maintain these complex systems?

**A.** The present design objective is to make systems less complicated. The next generation of airplanes should be easier to maintain but will perform more functions.

**Q.** How do you meet the problem of maintaining a highly complex system in the field?

**A.** Some airframe manufacturers have set up a reliability group whose duty it is to investigate all failures. This group must have the power to go to the top people, if necessary, to get improvements made in any phase of the weapon system, including ground support equipment, test equipment, procedures, and the aircraft itself. Research is being done to simplify test equipment and procedures.

## Test Equipment

The problem of calibrating test equipment is present in every testing job in this country. Most labs have signal generators, frequency meters, power measuring devices, meters, and the like, which are capable of generating signals from very low frequencies to extremely high ones, measuring power outputs from a few microwatts to several million watts, counting events in tenths of microseconds, or measuring magnetic flux shift per hour. But we have completely outdistanced our standards of measurement.

We need a completely new set of standards, recognized and accepted by all manufacturers of electronic equipment. We need a readily available timing device of unquestioned accuracy to measure a

hundredth of a microsecond, a power measuring device for calibration of test equipment from a millionth of a watt to 2,500,000 w; we need pressure measuring standards and gauss measuring devices far more accurate than those available.

The National Bureau of Standards services are valuable; they were indispensible in the yesteryear of the mechanical revolution, but they have been bypassed in both directions in the present year of the electronic revolution.

The unfortunate end-user who attempts to work two or more systems with or against each other is confounded by the lack of universal agreement on parameters. A computer built by one organization, a radar built by another, and test equipment built by a third are apt to result in conflicting information from each piece of equipment, with no way to tell which unit is outside the established tolerance. But they all have tolerances of one kind or another and must be tested by special test facilities which in turn have tolerances which must be calibrated by standards.

**Q.** What are equipment manufacturers doing to standardize on values?

**A.** Much research and coordination is going on between equipment manufacturers. Committees are working on this problem and trying to establish uniform standards which will meet today's demand for close tolerance devices.

**Q.** Are we going too far with requirements to meet absolute measurements in our systems? Would it not be well to try the end item for performance rather than to meet exact tolerances?

**A.** Engineers write specifications requiring equipment to meet these measurements. Contracts are written with these tolerances as a basic requirement for acceptance. Perhaps a relaxation of these specifications and contracts might help to achieve the end function of an operational piece of equipment.

**Q.** What progress has been made with self-testing features and built-in testing circuits?

**A.** These items will be built into equipment as the necessary weight and space can be afforded.

**Q.** What about the concept of go-no-go testing?

**A.** This is the ultimate goal of test equipment. Go-no-go testers will relieve the technician of the responsibility of deciding whether a system is within operational tolerance. It is a problem to build such testers without their being so complex as to require highly trained technicians to maintain them.

**Q.** What is being done to insure the delivery of testing equipment simultaneously with the delivery of airborne equipment?

**A.** This is quite a problem when the equipment is procured by the Armed Services because test equipment is generally procured by a different agency than the airborne equipment. When possible, aircraft manufacturers might improve the situation by including the requirement of simultaneous delivery in their contracts.

**Q.** What is being done to simulate the completion of a test when that test cannot actually be accomplished? For example, how do you test for firing and flight conditions of a missile without actually firing it?

**A.** Actual operations are carried up to the point where firing would occur. After that, signals are put into navigators and computers which duplicate the actual signals encountered in a typical flight. Then equipment is checked for resultant answers.

## Personnel and Organization Problems

To set up an organization to handle weapon system contracts, unusual steps may have to be taken to find a source of trained personnel. If a particular labor market is exhausted, a recruiting group must visit other areas. The short-term or three-year colleges are a fertile field for procuring manufacturing technicians. These men lack the proper degree from an accredited school to be hired as full-fledged design engineers, but they have been found to have excellent training, to be ambitious, eager, and energetic.

In one instance, these men were hired as manufacturing engineers and assigned as helpers to the design engineers for a period of several months. After that, they participated in the building of test equipment while they were being trained in a particular system. Then they followed the test equipment to the aircraft assembly line where they became experts in operating, troubleshooting, and improving the equipment in their assigned system. Some of the men were allowed to return to the engineering section as design engineers, others progressed to higher rated jobs in manufacturing or advanced to supervisory jobs.

It is almost impossible to find people who can step right into highly specialized electronic system jobs. Regardless of prior experience or training it is always necessary to give in-plant training to acquaint them with the particular system to which they are assigned. College students are sometimes given on-the-job training during summer vacation, and part-time work during the school year, with a firm offer of employment on graduation. Often it is advisable to send trainees to a system supplier's factory for job training on the electronic equipment furnished to the aircraft manufacturer.

**Q.** Are graduates of radio and T.V. schools generally hired for top technical work?

**A.** Not generally, but occasionally the school will recommend an outstanding pupil and he will be interviewed and hired.

**Q.** What other sources are there for technical people?

**A.** One company gave its nontechnical workers I.Q. tests and other examinations by which means they selected 80 people whom they believed could qualify for technical training. Basic electronic schooling was given to these people and after nine months they were assigned to some of the basic electronic functions, thereby releasing more highly trained technicians for more technical work.

(This report together with 13 other panel reports are available as SP-317 from SAE Special Publications, 458 Lexington Ave., New York 17, N.Y. Price: $2 to members; $4 to nonmembers.)

## Tests prove need of more tests and later standards for proper

# Matching of

ONLY as all the facts about thermal efficiency of a van body are known can it be satisfactorily matched with a refrigeration unit to do a specific transportation job. Yet, separate series of tests by the U. S. Department of Agriculture and by ATA's Regular Common Carrier Conference point up widespread lack of matching of van and refrigeration units . . . and wide differences in performance of different van-unit combinations.

Even these limited tests indicate:

1. The buyer of refrigerated tractor-trailers today does not have the means of applying the exacting and complex procedures necessary to determine what he is getting when he buys a trailer . . . or what protection it will give to frozen cargoes; and
2. Need for development of a standard method and apparatus for determining heat gain and air infiltration of refrigerated trailers, both new and used, in the laboratory and on the road.

Both the USDA and the RCCC tests emphasize the technical problem faced by the buyer of refrigerated tractor-trailers.

### The USDA Test Problem

An example is the recent USDA test made to answer a specific, but typical, question:

"How much space is it necessary to leave around a load of frozen pies and pre-cooked meals to provide adequate cold air circulation to maintain 0 F commodity temperatures?"

(The shipper sought lower transportation costs by increase of load weights . . . which was feasible because the pies and dinners are of low-weight density, and maximum allowable trailer weights are considerably above experienced load weights.)

### The Test Vehicles

Selected for the test were four modern 35-ft trailers. They were equipped with identical 5-ton capacity refrigeration units. Each trailer had strips on the interior nose, walls, and doors to facilitate air circulation. All were constructed with 6 in. of insulation in the floors, walls, and ceilings. They were made comparable in every respect.

### The Test Itself

The dinners and pies were loaded at –12 F.

Trailer No. 1 was loaded from the floor and to within 16 in. of the ceiling. Trailer No. 2 was loaded from the floor to within 4 in. of the ceiling. Trailer No. 3 was equipped with removable aluminum floor racks and loaded to within 16 in. of the ceiling. Trailer No. 4, also equipped with aluminum floor racks, was loaded to within 4 in. of the ceiling.

The trailers moved together over a 1200-mile trip with an outside average temperature of 71 F. Thermostats on the refrigerating units were set at 0 F throughout the trip.

In trailer No. 2, with a full load from the floor to within 4 in. of the ceiling, average commodity temperature at destination was 11.6 F. In trailer No. 4, similarly loaded to within 4 in. of the ceiling but with floor racks, average commodity temperature at destination was 18.2 F.

In trailer No. 1, loaded from the floor to within 16 in. of the ceiling, average commodity temperature at destination was 15.3 F, and in trailer No. 3, where floor racks were used and loading was to within 16 in. of the ceiling, the average commodity temperature on arrival was 9.1 F.

You will recall the cargo was loaded at –12 F. The average air temperature at the top rear positions within the trailers was 16.5 F; at the bottom front positions it was 10.3 F; and at the bottom rear positions it was 10.8 F.

Only at the top front positions within the trailers, directly in line with the refrigerating units, was a 0 F average air temperature maintained.

Greater increases in commodity temperatures were noted in the bottom layers of all loads than in the top layers.

In those trailers equipped with floor racks the average bottom commodity temperature at destina-was 14.6 F. The top average was 12.7 F.

Where racks were not used, the bottom average temperature at destination was 18.5 F, and the top average, 8.4 F.

Based on paper by Harold D. Johnson, Marketing Research Division, USDA

# Van Bodies and Refrigeration Units

The comparative temperature statistics in this particular test revealed no definable relationship or correlation between available space for cold air circulation around the load and commodity temperatures. The only conclusion that can be drawn from the results of this 4-trailer test is that the van bodies and refrigerating units were not so matched as to provide the shipper and carrier with a total transport unit to move all the cargo at desired temperatures. The cold air circulation provisions of the trailers could not in themselves overcome the disadvantages inherent in this unmatched combination.

### The RCCC Tests

The Regular Common Carrier Conference Tests focused even more directly the need for standard ratings for trailers and refrigeration units. They were specifically proposed, in fact, to determine relative heat transmission, temperature pulldown rates, and warmup rates of participating trailers . . . and to indicate a range of performance characteristics for the trailer-refrigeration unit combinations submitted.

### The RCCC Test Vehicles

For these tests were selected seven commercial, insulated, new, refrigerated semi-trailers of nominal 35-ft length. The makes were: Dorsey, Fruehauf, Great Dane, Highway, Lufkin, Miller, and Trailmobile.

Four of the trailers were equipped with Thermo King refrigerating units, all model RL-30's. In the trailers were a Coldmobile, a Tru-Kooler, and a Transicold unit.

**All van-and-cooling-unit combinations were submitted by manufacturers, with the specification that they were to be so matched as to maintain 0 F interiors when empty and parked in an open lot at 100 F outside temperature.**

**All trailers were covered with bright aluminum exteriors. They were offered by the manufacturers as competitive trailers designed to give comparable service to the buyer.**

The tests were made under comparable conditions and by well-qualified government personnel.

### Tests Results

Wide variations in performance of these presumably equally-well-matched trailer-refrigerator units showed up in each of the five types of test made. Variations among the seven units, ranged as follows:

| | |
|---|---|
| Heat Transmission: | 43% . . . from 75 to 107 btu/hr |
| Solar Heat Gain: | 345% . . . from 230 to 1020 btu/hr |
| Warmup Time from 0 F to 70 F: | 55% . . . from 14.7 hr to 9.6 hr |
| Pulldown Time from 91 F to 0 F: | 460% . . . from 2.7 hr to 15.1 hr |
| Refrigerating Unit Capacity: | 150% . . . from 6400 to 15,900 btu/hr |

There was no one trailer that out-performed all others on all tests. Some performed quite well on some tests; poorly on others.

This points up the fact that no one of these tests in itself gives an adequate indication of the overall performance to be expected from a trailer refrigerating unit combination.

Determination of pertinent thermal characteristics of the trailer is the first logical step to take in matching a refrigerating unit to a trailer. . . . And laboratory and over-the-road studies are needed to establish requirements. Standard test methods and apparatus must be devised to evaluate performance of trailers both when new and at intervals throughout their service life. Coordinated industry and government action on such studies can result in better matching and use of trailer-refrigeration units.

(Paper, "Refrigerated Van Bodies for Frozen Food Transport," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# Nose proves best tool for . . .

# Evaluating Diesel

Based on paper by **F. G. Rounds and H. W. Pearsall,** General Motors Research Staff

DIESEL exhaust gas has been most successfully evaluated in recent tests by the so-called direct odor technique. It is simpler than the dilution technique, which requires precise metering of small gas flows, and more reliable than predicting odor intensities by analysis of exhaust gas.

## Dilution Technique

When the man in the street smells diesel exhaust he is getting an air-exhaust gas mixture rather than straight exhaust. Consequently, the first approach was to evaluate increasing dilutions of exhaust gas in the air until the characteristic odor could no longer be detected. In individual tests, a small flow of exhaust gas was measured, mixed with a measured flow of clean air, and passed into a sniff box for evaluation by a panel.

The sniff box is a clear plastic box of 0.5 cu ft capacity, so designed that a panelist could insert his head for sniffing without encountering stray air currents. Between evaluations the box was flushed with a continuous stream of gas to renew the sample.

Samples of gas were supplied by four open-chamber diesel engines. (See Table 1.) Samples were taken at a tee in the 4-in. exhaust pipe about 16 ft from the exhaust manifold, then passed through 4 ft of 7/16-in. copper tubing, a water-cooled exchanger, 10 in. of 7/16-in. Tygon tubing, to enter the sniff box at the bottom through a metal diffuser plate (Fig. 1).

In most tests panel members numbered five and each member rated his impression of odor and irritation intensity of the sample. Individual ratings were given numerical weights, which were averaged to obtain the final value. Odor intensity was estimated according to an "odor unit" scale that ranged from 0 for no odor to 5 for a very strong odor. The irritation intensity scale ranged from 0 for no irritation to 4 for a strong irritation.

Reproducibility by the dilution technique was reasonably good. Data show the characteristic odor was not eliminated until a dilution ratio of about 0.01 was reached. Reproducibility of irritation intensity estimates was also satisfactory. Data show irritant properties of these exhaust gases disappearing at dilutions beyond about 0.06. Substantially less dilution was required to remove the irritant properties than the odor.

There are three serious disadvantages in the dilution method:

1. Metering small exhaust flows is difficult and subject to error.
2. The metering apparatus and sniff box must be cleaned very frequently.
3. Maintenance of constant engine conditions while studying several dilutions can be difficult.

## Direct Technique

The undiluted or direct technique replaced the dilution method when tests showed the order in

**TABLE 1—Dynamometer-Mounted Diesel Engines Used in Odor Studies**

| Engine | Type | Displacement, cu in. | No. of Cylinders | Nominal Compression Ratio | Combustion-Chamber Design | Service Life |
|---|---|---|---|---|---|---|
| A | 2-Stroke | 426 | 6 | 16.0 | Open Chamber | 300 hr on dynamometer stand |
| B | 2-Stroke | 426 | 6 | 16.0 | Open Chamber | About 300,000 miles total. About 100,000 miles since overhaul |
| C | 4-Stroke | 673 | 6 | 16.6 | Open Chamber | New engine after run on dynamometer |
| D | 4-Stroke | 505 | 6 | 17.0 | Open Chamber[a] | About 200 hr on dynamometer stand |

[a] The injected fuel impinges on the piston at about a 30-deg angle.

# Exhaust Odor

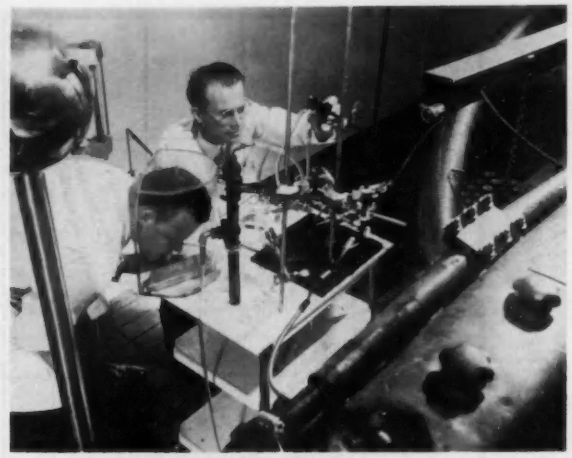

Fig. 1—Equipment used to evaluate diesel odor by dilution technique. Sniff box was also used in direct technique studies.

which engine test conditions rank with respect to odor intensity to be generally the same whether estimates were made on equally diluted samples (say a dilution ratio of 0.30) or on undiluted samples.

To determine the reproducibility of estimates made by this direct method, repetitive tests were run in one of the engines at four conditions. The standard deviations of the odor estimates were similar for all four engine conditions, and the numerical values happen to be about the same for both the odor intensity and irritation intensity estimates. From these data (see Table 2) it is concluded that panel-average estimates, based on limited observations of undiluted exhaust from a single engine at different conditions, must differ by at least 0.5 odor or irritation unit before intensities at the two conditions can be considered to differ significantly. When two different types of engines are compared at a single operating condition, possible differences in the quality and intensity of odor or irritation introduce an added complication. Therefore, the range of uncertainty is somewhat greater than the 0.5 unit.

Engine load has a significant effect on odor (Fig. 2). The least odorous condition occurs in the mid-load region; the most odorous at full load or, for some speeds, at no load. No consistent effect from engine speed was observed. Fig. 3 shows that irritation intensity is similarly influenced by load. Note that the effect of load was greater on irritation intensity than on odor.

The direct technique does have some inherent difficulties. It requires less time than the dilution method, but it is still slow and tedious. The quality of the undiluted exhaust odor may influence the intensity estimates. And, finally, since undiluted gases contain significant amounts of toxic materials at some engine conditions, long continued testing is undesirable. However, panel members suffered no ill effects.

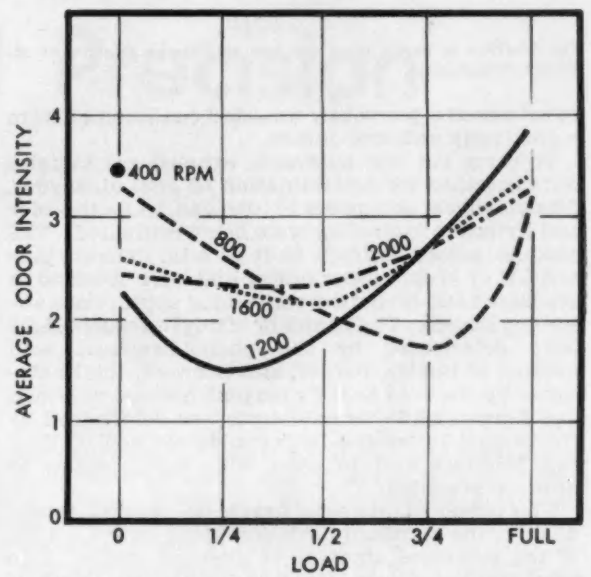


Fig. 2—Effect of engine speed and load on odor intensity of undiluted exhaust gases.

**TABLE 2—Reproducibility of Direct Odor and Irritation Intensity Estimates (Engine C)**

| Engine Speed, rpm | Load | No. of Tests | Average Intensity | Standard Deviation |
|---|---|---|---|---|
| Odor intensity (5 man panel) | | | | |
| 2000 | Full | 8 | 2.76 odor units | 0.26 odor unit |
| 2000 | Half | 9 | 2.42 odor units | 0.27 odor unit |
| 1000 | Full | 7 | 2.77 odor units | 0.33 odor unit |
| 1000 | Half | 6 | 2.47 odor units | 0.24 odor unit |
| Irritation Intensity | | | | |
| 2000 | Full | 8 | 2.84 irritation units | 0.25 irritation unit |
| 2000 | Half | 9 | 2.14 irritation units | 0.39 irritation unit |
| 1000 | Full | 7 | 2.93 irritation units | 0.22 irritation unit |
| 1000 | Half | 6 | 2.29 irritation units | 0.22 irritation unit |

## Chemical Analysis Technique

The analytical approach to the problem of evaluation is to find one or more constituents that vary in a systematic, known way with the intensities as determined by a panel. If such a general relationship is established, chemical analysis might be used to predict the odor or irritation intensity of the ex-

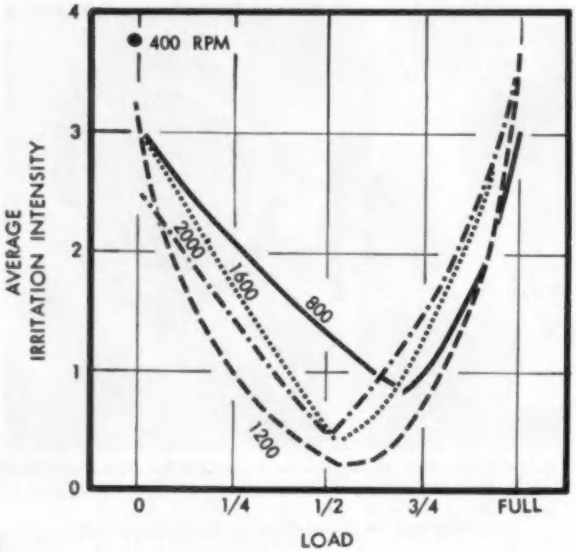


Fig. 3—Effect of engine speed and load on irritation intensity of undiluted exhaust gases.

haust gas at a previously untested condition or from a previously untested engine.

To carry out this approach, exhaust gas samples were obtained for determination of total aldehydes, formaldehyde, and oxides of nitrogen, while the odor and irritation intensities were being estimated. The samples passed through 16 ft of 4-in. exhaust pipe and 5 ft of ¼-in. copper tubing and were obtained in evacuated 500-ml bottles containing appropriate absorbing liquids. The oxides of nitrogen (except $N_2O$) were determined by the phenoldisulfonic acid method of Beatty, Berger, and Schrenk, total aldehydes by the acid Schiff's reagent method of Busch and Berger, while formaldehyde was determined by the phenyl hydrazine-ferricyanide method of Kersey, Maddock and Johnson, with modifications to improve precision.

The oxides of nitrogen proved to be very reproducible, the standard deviation being only 4.7–6.2% of the measured amounts of nitrogen oxides. The total aldehydes were less reproducible, the standard being 13.7% of the measured values, while formaldehyde analyses were still more variable. (See Table 3.)

Concentrations of total aldehydes and formaldehyde tended to reach minima at part load and maximum at full load. Concentrations of higher aldehydes and oxides of nitrogen tended to increase with load, the latter almost linearly up to about three-quarters load. At engine speeds above the idle setting, speed had little effect on the concentrations of the measured constituents.

Although statistically significant correlations were obtained between certain chemical analyses and the odor or irritation intensity, the question remains as to whether analyses of an unknown sample of exhaust gas can be used to predict reliably the odor or irritation intensity of the sample. To answer this, the standard error of estimate was calculated for each line of regression.

For the constituents giving the best correlation, higher aldehydes plus formaldehyde, the observed odor intensity data would be expected, at the 95% confidence level, to fall in a band having a width equal to four times the standard error of estimate or 1.6 odor units. The band would center on the line of regression. Since the total spread of the observed intensity estimates was 2.4 and 2.7 odor units for engines A and C, respectively, the expected variation in the odor intensity for a fixed exhaust gas composition is 60–70% of the total observed spread in odor intensity measured at different compositions.

A similar analysis of the irritation intensity data indicates that the variation in intensity values at a fixed exhaust gas compostion represents 70–90% of the total spread in the observed irritation intensity data.

For these reasons, the concentration of the constituents measured in the present study cannot be used for reliable prediction of changes in odor or irritation intensity which would accompany changes in factors such as the engine operating conditions, engine design, fuel or lubricant. The data also suggest either that constituents other than those measured are contributing significantly to odor and irritation, or that the chemical methods used are not doing an accurate measuring job.

Several attempts were made to see what could be done to reduce exhaust gas odor, but no panacea was found. For the present, close attention should be paid to improving engine and injector design, proper fuel and oil, good maintenance, and avoidance of overloading. Catalytic mufflers and masking agents may offer some promise for the future.

(Paper, "Diesel Exhaust Odor—Its Evaluation and Relation To Exhaust Gas Composition" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

**Table 3—Reproducibility of Chemical Analyses**

| Engine | Load | Speed, rpm | Compounds Analyzed | Number of Determinations | Average Content, ppm | Standard Deviation, ppm | Coefficient of Variation, % |
|---|---|---|---|---|---|---|---|
| A | Full | 2000 | Oxides of nitrogen | 6 | 954 | 44.7 | 4.7 |
| C | Full | 600 | Oxides of nitrogen | 10 | 630 | 39.0 | 6.2 |
| A | Full | 2000 | Total aldehydes | 8 | 95 | 13.0 | 13.7 |
| A | Full | 2000 | Formaldehyde | 9 | 43 | 16.6 | 38 |
| C | Full | 2000 | Formaldehyde | 18 | 18.3 | 4.2 | 23 |
| C | Half | 2000 | Formaldehyde | 19 | 8.2 | 4.0 | 49 |
| C | Full | 1000 | Formaldehyde | 15 | 26.3 | 7.7 | 29 |
| C | Half | 1000 | Formaldehyde | 10 | 5.7 | 4.0 | 70 |

# Transparent Cockpits Need High Optical Precision

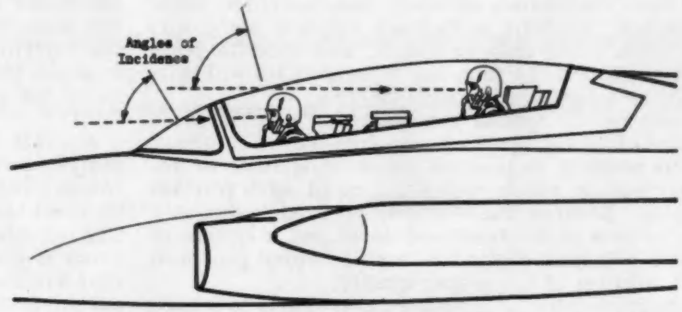


**Fig. 1—The viewing requirements of tandem seating demand near optical perfection despite the difficulties presented by two different angles of incidence.**


Based on paper by **L. F. Bonza,** Lockheed Aircraft Corp.


SO THAT a pilot will not be distracted by any sort of distortion that would delay his reaction time or cause him to misjudge distances, transparent cockpit enclosures require special materials, designs, and production techniques. New concepts and materials will be necessary as temperature requirements increase to 600 F.

The two principal reasons why optical quality has assumed added importance in recent airplanes are:

1. Increased speeds.
2. Cockpit streamlining.

The higher speeds common to today's aircraft leave less margin for pilot misjudgment. Therefore, the pilot must not be distracted by any sort of optical distortion which could fatally delay his reaction time or cause him to misjudge the location of a runway.

Cockpit streamlining lowers the angle of panel installation, a condition which amplifies optical defects. So, every time more streamlining is introduced, optical requirements become more critical.

In the case of higher-speed airplanes a similar situation results because streamlining and reduction of frontal area necessitate increasing the angle of incidence (shallow mounting). The importance of the angle of incidence condition can be illustrated by listing a few examples. At an angle of incidence of 50 deg the deviation is twice the value at normal incidence; at an angle of 70 deg the deviation is multiplied 4.8 times; and at 80 deg it is multiplied 10.9 times. Distortion, which is defined as the rate of change of deviation, is magnified even more because every inch of glass surface is now in effect reduced to the projected length as far as an observer is concerned.

Another factor which places an additional demand on optical quality is the location of the observer or eye point. The reason for this is that the farther away the observer, the more glass area that is used to view a particular object. This means that the high quality of the enclosure surfaces must be continuous over longer distances in order not to produce distortion. It is therefore desirable to design enclosures with the observer as close to the sighting surfaces as is consistent with comfort and other requirements.

Canopies have been produced extensively in the past by free-blowing. This process is fine because the material in the sighting areas touches nothing but air and thus is only subject to the material quality limitations. However, some sighting areas must be of extremely good optical quality. This is especially true when the viewing requirements of tandem seating are imposed (Fig. 1). It is known, however, that the effects of irregular holddown rings can manifest themselves as far as six or more

inches into the clear area. Therefore, to produce these parts satisfactorily, extra careful selection of stock must be made and the tooling holddown rings must be refit and refinished to a degree far beyond previous requirements.

The production of satisfactory canopies which do not have free-blown contours has presented other problems. Current technology requires some sort of a mold, either male or female, and since the plastic must touch the tool, any irregularities will naturally be transferred to some degree.

Until recent special requirements were imposed on the sighting areas of non-free-blown canopies, it was possible to produce parts using male or female tooling which were lubricated with various greases. Because these systems proved inadequate for the new parts, Lockheed developed a system of optical polishing of the tool surface which produced a smoothness of the proper quality.

The production of laminated glass parts to a high optical quality has been accomplished by several means. Closer control of the procedures used in tempering and laminating has contributed toward improvement; extra care in preventing scratching or damage which requires repolishing has helped. However, to produce parts which meet a requirement as close as ½ min of deviation, regrinding and repolishing have been the only operations found adequate. Previously these operations were limited to annealed glass, but recently they have had limited success on semitapered plates. As far as is known, no production system has been developed in this country to regrind and repolish curved aircraft parts.

The materials which are in common use today appear to be limited to a temperature of 250 F and actual performance at this temperature is even considered marginal. The temperature limit of about 250 F is for the rigid transparent plastics. The limiting temperature for some designs which use polyvinyl butyral for laminating the rigid faces is about 180 F. Since glass is nearly always laminated for safety reasons, it too has the same 180 F limit.

Aircraft that are under consideration now have temperature requirements far beyond the 250 F range. Temperatures of 550–600 F will be common. To meet this kind of condition new concepts of design or new materials will have to be introduced. From a practical standpoint, however, it is likely that known materials will be adapted by ingenious design to function until more straightforward applications can be made.

(This article is based on one of four papers presented by a panel on transparent materials. Other speakers were: **J. G. Stansbury,** Swedlow Plastics Co.; **L. B. Norwood,** North American Aviation, Inc.; and **C. O. Deacon,** North American Aviation, Inc. The report of this panel is available in full, together with reports of 13 other panel sessions of the SAE Aircraft Production Forum. This publication, SP-317, is available from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: $2 to members; $4 to nonmembers.)

# Corrosion, Abrasion . . .

**. . . may account for lion's share of engine wear in average passenger-car service. That's the wear pattern found in recent extensive tests.**

Based on paper by **H. R. Jackson,** Atlantic Refining Co.

OILBORNE abrasion and low-temperature corrosive wear may account for the lion's share of the total wear being experienced in passenger-car engines being driven in average service. At least that's the wear pattern found for 12 vehicles driven in a certain manner in the Philadelphia area. Under the actual conditions of the tests, the figures came out to 50 wear due to oilborne abrasion, 45% due to low-temperature corrosion, and 5% from other causes.

Of course, under different conditions of weather, fuels, lubricants, type of driving, cars used, oil and filter change practices, and the like, the percentages might be quite different.

For example, oil and oil filters were changed every 5000 miles in the test. If a 1000-mile oil change had been used, abrasive wear, and therefore total wear, would have been greatly reduced. This would have raised the percentage contribution of corrosion.

On the other hand, operation in a warmer climate wtih longer oil changes and no or nonoperational oil filters would have greatly increased the relative contribution of abrasive wear to the total. (Actually, average temperature for the test was 53 F.)

As an example showing how much effect these types of variables have on wear, it is interesting to look at the range in actual wear rates obtained in the 12-car program. The 12 lowest rates of wear averaged but 6 mg per 1000 miles. This rate occurred at an average temperature of 67 F, an average of 1600 miles since oil change, and with an average of 42 miles driven per day. The 12 highest rates of wear averaged 154 mg per 1000 miles, at an average temperature of 41 F, an average of 3500 miles since oil change, and an average of 37 miles per day. The average total wear in the tests was 45 mg per 1000 miles. It was determined (by methods discussed in the complete paper) that 20 mg of this was caused by corrosion alone, 23 mg of oilborne abrasion, and 2 mg was caused by other factors.

(Paper, "Why Does Your Car Wear Out," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# "You're a Knucklehead" . . .

## . . is hurled from engineering to manufacturing and back again less often when quality control data gives engineering the "natural tolerances" of production processes.

Based on secretary's report by **L. S. Eichelberger,** A. O. Smith Corp.

QUALITY control can bring to reality the much-heralded, hard-to-get "cooperation" between manufacturing and engineering departments. With measurements for quality set up, manufacturing can state in positive language what it can do consistently. And that statement can be made in terms usable to engineering in making its decisions.

The prime responsibility for product quality must always lie with the manufacturing people, of course. They make the product. They are expected to make it right. But to make it right, they have to know:

a. What is right
b. How to measure right from wrong
c. How to correct a "wrong."

When manufacturing gets a blueprint, it gives it to an operator, already furnished with tools and equipment, and expects him to make the part. If he does, no problem arises.

But all too frequently the operator misses his objective. Sometimes the miss is his fault. Many times it is not. The equipment and the blueprint don't always work together.

Then the engineering department is notified that the shop can't make the part . . . and it rarely gets any new information along with the bad news. So, engineering concludes that the part could have been made if only those fellows down in the shop weren't such knuckleheads.

The shop, of course, takes the view that the engineers who sent down an unworkable blueprint are the knuckleheads.

That's where quality control can furnish the missing ingredient needed to break the impasse—a measure of the capability of the shop . . . a measure that the engineer can rely on. The engineer isn't averse to opening tolerances, if he can be sure in advance that the shop can hold the new tolerance. (What he objects to is opening his tolerance one week, and getting a request for a second inch a week later.)

Statistical techniques now provide a means of measuring the shop's capabilities. It can be done by the following steps:

1. Using a quality control chart to help eliminate erratic fluctuations in the manufacturing processes.
2. The resulting stable and predictable variation provides the measure of the capability of a process to do a job. It defines the "natural tolerances" of a process . . . and these can be compared to blueprint tolerances.
3. If the natural tolerance is wider than the blueprint tolerance (and it often is) one of three things must be done:
   a. The engineer must open his drawing tolerance to make the two tolerances compatible
   or
   b. Production must be sorted to remove the out-of-tolerance pieces
   or
   c. The process must be redesigned to decrease the natural tolerance to fit the blueprint tolerance.

It is usually least expensive to have the engineer change his drawing tolerance. So, he has to weigh all of his engineering judgment and know-how against the fact that the shop said it cannot do what he has asked. . . . But he is in a good position to make his very important decision now, because the shop has also told him in positive language what it CAN do . . . not just what it can't.

When the engineer gets this quality control information in the early stages of his design, he is even better off. Then he can make his original designs with a better knowledge of process capabilities and natural tolerances.

In any case, the final decision rests in the economics of the particular situation.

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Members of the Quality Control panel from which the material in this article was derived were: **H. L. Rittenhouse,** Euclid Division, GMC, chairman; **L. S. Eichelberger,** A. O. Smith Corp., secretary; **Floyd Diehl,** International Harvester Co.; **William Esty,** Wisconsin Motors Corp.; **P. J. Lindley,** Allison Division, GMC; and **S. R. Seidler,** Deere Mfg. Co. Secretary Eichelberger's full report, together with 7 other panel reports from this 1956 Tractor Meeting Production Forum are available as SP-316 from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: $1.50 to members; $3.00 to nonmembers.

Here are a dozen steps trailer manufacturers could take to reduce

# Trailer Maintenance Problems

Based on paper by

**Andrew Ambli,** Briggs Transportation Co.

THOUSANDS of dollars in maintenance costs could be saved if trailer manufacturers would direct their attention to changing design and manufacture in five trouble areas. These are:

- Greasing points.
- Door holdbacks.
- Open tops.
- Floors.
- Insulation.

Greasing trailers in winter is a major problem. The fittings are hard to find, let alone grease. There isn't time to run a trailer into a warm room to thaw. If we use steam or hot water the brake linings get wet and freeze up when taken outdoors. The attempt at servicing isn't the only cost; it is also the wearing out of parts due to irregular servicing. At the moment, nylon bushings are common on trailers, but their disadvantages far outweigh their advantages because sand and water enter if they are not serviced regularly.

Sealed roller bearings would appear to answer this problem.

Greasing sliding tandems creates a special problem. Ordinary tandem slides are made of carbon steel. They collect dust and dirt when greased, hence score very easliy. If they are not greased, they stick and you can't move the tandem.

This problem could be licked by using stainless steel or a nonrusting material.

Use of bushings and grease fittings on the upper, or cranking, shaft of a dolly is ridiculous and should have been stopped eight years ago. The shaft has a cranking speed of approximately 40 rpm.

A steel roller bearing is the answer here.

The dolly itself never gets the right lubrication to begin with. One of the newer greases would solve this problem. During the last war a steering gear lubricant was developed for heavy-duty equipment in Alaska which allows free turning at −60 F and good lubrication at 100 F. Later Greyhound requested a special lube for power steering. A cheaper grease was developed by eliminating the synthetics. The dolly must be packed with this type of grease at the factory with filler plugs, not grease fittings. After that, checking once or twice a year would be adequate.

Trailer interchange creates a problem as great as any. Trucking companies practice interchanging equipment to facilitate delivery. Naturally, the interchanged trailer doesn't get proper servicing since it does not belong to you.

A greaseless trailer, or one on which greasing was kept to the barest minimum, would solve this and all other greasing problems.

Door holdbacks are the No. 2 problem. There are no good ones. We have trailer doors costing $200 a piece, yet we try to depend on 10¢ holdbacks to prevent damage to the door and protect our investment.

The answer here is a door holdback designed for strength and hard use. The trailer owner would be willing to pay what it costs.

Trailer manufacturers haven't spent any time or energy in developing a good open-top trailer. The standard top isn't even fit to use when it comes off the production line and the maintenance is terrific, especially of bows and tarpaulins. No manufacturer has yet come out with a standard trailer equipped with anything except a sliding roof.

Since the sides of the trailer will spread anywhere from ½ to 1 in. when loaded, which makes it almost impossible to replace the pin, the drivers will either throw the header away or leave the pin out. This can be costly for maintenance because the sides of the trailer will crack eventually if the header is left out.

The answer to this problem is the split header (Fig. 1). It is so designed that even if the sides of the trailer spread 2 in. there is enough play in the clamping device to hook the header and pull it together.

A standard open-top trailer is made and equipped with solid bows. The primary disadvantage of this is fairly obvious. Trailer sides are not manufactured accurately enough to allow a solid bow to be removed and replaced easily. Instead we should have an adjustable bow to serve just one function

—support the tarpaulin (Fig. 2). No trailer producer has ever been able to make bows strong enough to prevent the sides from buckling. Therefore, open-top trailers should have at least two fulcrum chains to prevent the sides from spreading. When fulcrum chains are not used, the sides split, which again adds to maintenance cost.

When there is a split header it is only natural to use three cables for tarp support. Otherwise the tarp will fall into the trailer between the bows. One of the biggest headaches of all fleets is trying to adjust tarps to fit the various lengths of trailers. This is easily remedied by using an adjustable tarp clamp (Fig. 3). It makes unnecessary heavy tarp ropes or tiedowns hanging over the rear door of the trailer. If this clamp is used, there is no need for carrying several lengths of tarps. If the tarp is long enough for the longest trailer, it will fit any of the shorter ones. If the tarp is too long, you need only double it under the clamp.

Trailer floors, whether made of stainless steel, aluminum, or wood, require maintenance. But very few are installed with that in mind. The hat-type section floor, widely used in open-top and "tin-top" trailers, is the only one made for repairing. It is economical and easy to maintain.

An aluminum floor would be great if it were manufactured so that part of it could be replaced without disturbing the entire floor. At present, available aluminum floors are too costly for maintenance.

The strength of a floor is determined by the cross-members and their spacing. Cross-members should have 12-in. spacing, or at least a spacing which conforms to the standard measurements of available materials. By uniform spacing we can determine floor capacity accurately. Some trailers have 10-ft length plywood installed in the sides, which is not

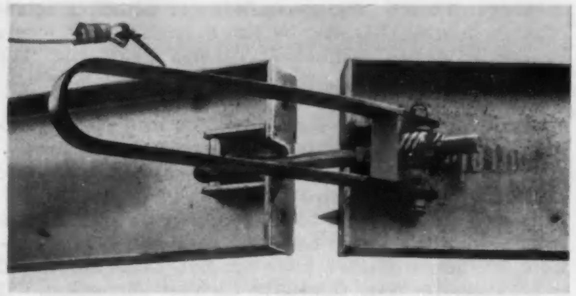


Fig. 1—Split header lock in open position seen from inside a trailer. Designed to permit clamping even if the sides of the trailer spread as much as 2 in., and to replace the customary unworkable pin.

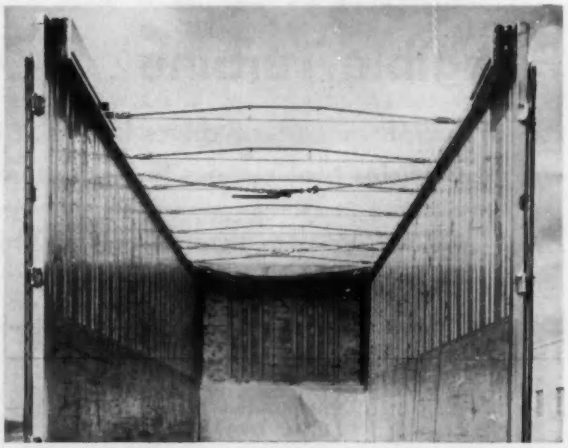


Fig. 2—Rear view of split header in open position, adjustable bows to support tarpaulin, and fulcrum chains to keep trailer sides from spreading.

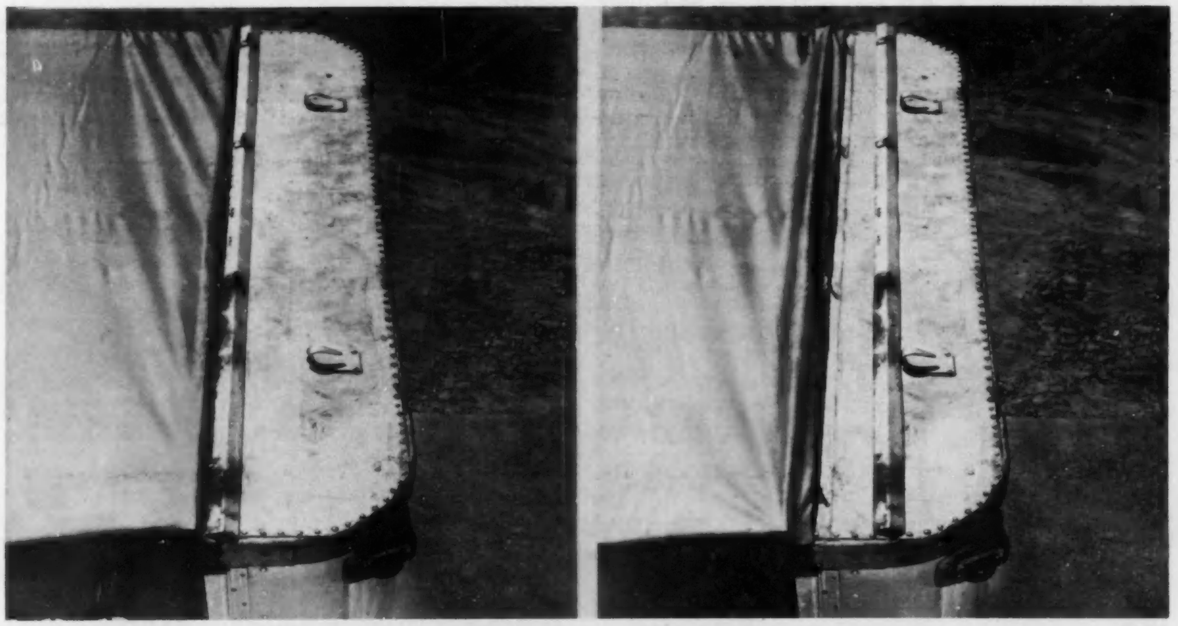


Fig. 3—An adjustable clamp cures headaches caused by trying to adjust tarpaulins to fit various lengths of trailers. It also puts an end to tarpaulin ropes and tiedowns hanging over the rear door. (Left) clamp in position; (right) clamp removed.

a standard size. The manufacturer achieves economy in buying this size by the carload, but it costs extra money to replace it in the field with the standard 8-ft length, which often is the only size available.

Standardization of material sizes and floor spacings is of vital importance in floor maintenance.

The last problem in the five areas discussed here is the maintenance of an airtight insulated trailer. It is well known that to accomplish its purpose an insulated trailer must not have even the tiniest pinhole. When a trailer is in transit, both sides and especially the roof fluctuate like an accordion. If the plywood is not properly installed with backing and flashing to seal it airtight or incorporate the Thermo Seal the air will pump from the inside of the trailer regardless of insulation thickness. No matter how much insulation is installed, it will have little value if air is allowed to travel back and forth. This shows up in maintenance costs. In a short time the insulation will fill up with dust and dirt and, of course, will have very little value. In many instances it has to be replaced.

(Paper, "The Future of Trailer Maintenance," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# Frangible Turbine . . .

## . . . for aircraft air turbine drives bursts at a predetermined overspeed into small, lightweight particles that can easily be contained in a casing only 0.045 in. thick.

Based on paper by **W. W. Houghton and E. R. Phillips,**

Advance Engineering Unit, Aircraft Accessory Turbine Dept., General Electric Co.

THE "frangible" wheel was designed to the following operating requirements:

Normal rated speed—30,000 rpm
Maximum control speed—40,000 rpm
Burst speed—60,000 to 65,000 rpm
Maximum operating temperature—750 F
Maximum inlet pressure—250 psig
Maximum shaft power—25 hp

The final design which was arrived at to satisfy these requirements consisted of an alloy steel turbine wheel disc and hub to which were attached very light-weight titanium blades. These blades were attached to the turbine disc by means of alloy steel pins so designed that the pins would shear and blades be ejected at the desired burst speed. Since the burst speed was accurately controlled and the weight of the wheel and blades reduced to a minimum, wheel containment was greatly simplified. For such an approach no increase in turbine housing weight is required, and 100% containment becomes possible.

Tests demonstrate that the turbine wheel sheds its buckets at the predicted speed and that these buckets are contained within the confines of the turbine casing.

(Paper "Successful Containment of High-Speed Turbine Failures" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

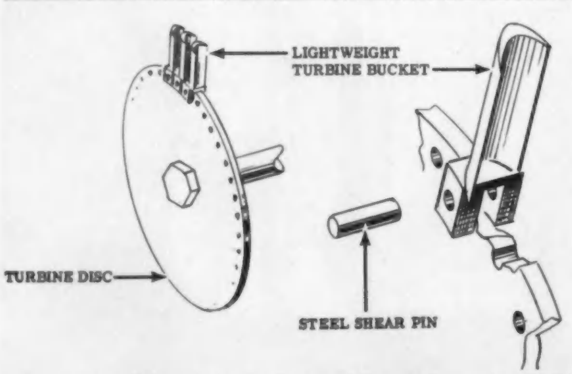



Fig. 1—Wheel is designed to shed its buckets at a predetermined speed.

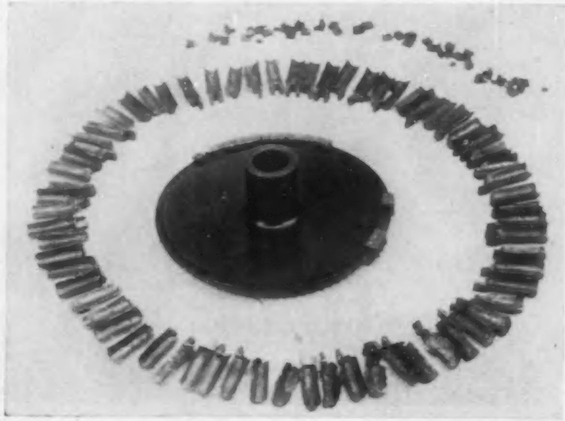


Fig. 2—Turbine wheel after burst demonstrates frangible design.

# SAE LOOKS OVERSEAS

by J. K. BANNON, British Air Ministry

**Results of British research on CLEAR AIR TURBULENCE are reported here by a leading engineer of the Air Ministry's Meteorological Office.**

CLEAR AIR TURBULENCE AT HIGH ALTITUDE was reported by military pilots during World War II and was therefore recognized as one of the many problems to be considered in planning the operation of the high-altitude civil flying which has developed during the last 10 years.

**MAJOR ALTITUDE PROBLEM**

Exploratory flights were made in a Spitfire aircraft from the Royal Aircraft Establishment, Farnborough, during 1946 to 1948 and an important investigation was carried out by the British European Airways Corporation with a Mosquito aircraft in 1948-50. From these investigations and from an analysis of reports of the phenomenon from military and other flights, some general results emerged:

- The degree of turbulence is usually considerably less than may be encountered in a thunderstorm and it occurs less frequently in the upper troposphere (above 20,000 ft) and lower stratosphere than does turbulence, of all kinds, at lower heights.

**THE LAYERS ARE SHALLOW**

- Turbulent layers are usually shallow, less than 2000 ft thick. However, some very severe bumps have been encountered.
- Turbulence has been encountered up to a height of 55,000 ft.

**"RIVERS" OF FAST AIR**

- Certain regions of jet streams - comparatively narrow "rivers" of fast-flowing air near the level of 30,000 ft - appear to be much more prone to severe turbulence than other weather regimes; workers in Canada and the United States have since confirmed this result for North America.
- Rough mountainous country is a contributory factor but clear air turbulence also occurs over the sea or flat terrain.
- However, the exact physical causes of high-altitude clear air turbulence are still unknown.

**"HAMMER" ON CRAFT AND ON PILOT**

- This turbulence often gives the impression of rapid and regular "hammering" on the aircraft and test pilots of Short Brothers & Harland, Ltd. have emphasized that it may sometimes cause yawing or tail-wag.

(continued on next page)

**This feature is an activity of the SAE OVERSEAS INFORMATION COMMITTEE, C.G.A. Rosen, chairman**

# SAE LOOKS OVERSEAS

(continued from page 69)

• These and other indications that turbulence at high altitude has a different nature from that occurring in the layers below 20,000 ft have caused concern among designers lest such turbulence should excite vibration in future aircraft which will have reduced damping and lower fundamental frequencies of vibration than present-day aircraft.

**MORE STUDY IS NEEDED**

Further information is clearly required. The nature of the gusts, magnitude, spacing, regularity and so on, in fact, the complete spectrum of the turbulence must be discovered as well as the geographical distribution and association of the turbulence with different weather situations. Instruments for measuring gusts are carried on aircraft of the Meteorological Research Flight operating from Farnborough and, though progress in this field is bound to be slow, it is hoped that some of the answers will be provided within the next few years.

# Coated Molybdenum-Base Alloys . . .

**. . . appear promising for jet engine parts operating up to 2000 F. Oxidation resistance at still higher temperatures is difficult to obtain.**

Based on paper by **R. T. Begley,** Westinghouse Electric Corp.

SEVERAL molybdenum-base alloys have been developed which exhibit higher useful strength at temperatures over 1600 F than any previously known materials. The magnitude of this superiority is indicated by a comparison of the 100-hr stress-rupture properties of two such alloys with several of the best conventional nickel and cobalt-base superalloys (Fig. 1).

The elevated-temperature ductility of molybdenum and its alloys is more than adequate for virtually any application. Final elongation in stress-rupture tests is generally 10% or greater, and reduction in area is usually over 50%. Molybdenum also has a high modulus of elasticity, a desirable property where buckling is a critical factor. Its high thermal conductivity is effective in reducing "hot spots" in components where non-uniform temperature distribution is a problem.

The high-strength molybdenum alloys now commercially available are solid-solution alloys which rely largely on strain hardening to achieve maximum strength. The creep-rupture properties of several arc-cast molybdenum-base alloys are shown in Fig. 2. The molybdenum 0.5% Ti composition is the commercially available one having the best combination of properties, although several experimental alloys have exhibited even greater high-temperature strength.

Recrystallization temperature is one of the most important characteristics of molybdenum-base alloys. Since they derive their excellent elevated-temperature strength through mechanical working, the recrystallization temperature sets an upper limit to the operating temperatures at which the beneficial effects of mechanical working can be retained.

The arc-cast alloys are now considered for applications in the jet-propulsion field because of availability and fabrication characteristics, although alloys with the equivalent high-temperature properties have been made by powder-metallurgy techniques.

Molybdenum's main disadvantages for aircraft application are:

1. Relatively high density.
2. Difficulty of obtaining high strength joints.
3. Absolute lack of oxidation resistance.

The density (approximately 25% greater than conventional turbine blade materials) is a real disadvantage, particularly in rotating components. However, the strength-weight ratio of molybdenum-base

alloys is still significantly superior to conventional superalloys at over 1600 F temperatures.

Conventional fabricating techniques can be used, but the problem of obtaining ductile high-strength joints has not been fully solved. Satisfactory welding methods have been developed for a number of applications.

The most serious obstacle to use in aircraft applications is the complete lack of oxidation resistance. Some form of protective coating must be applied if molybdenum is to be used in oxidizing atmospheres over 1000 F. The volatility of molybdenum trioxide prevents the formation of a protective oxide layer at elevated temperatures. Volatization begins at about 932 F and is very rapid at temperatures above 1450 F, resulting in a very large loss of surface. The nature of this oxide restricts the likelihood of discovering an alloy addition or additions which would form a protective oxide layer. A large number of binary and ternary alloys have been investigated without success. Some alloys studied have exhibited oxidation rates 100 times lower than unalloyed molybdenum, but significant improvement is still required. Moreover, the large amounts of alloy addition needed to improve oxidation behavior make the alloy too brittle to fabricate and drastically lower high-temperature strength. For this reason most efforts have been directed toward development of protective coatings.

Several coatings have been developed which provide protection for periods in excess of 100 hr at 2000 F, and for much longer at lower temperatures. No one coating has superiority under all conditions. The most promising are:

1. Electrodeposited Cr-Ni coatings.
2. Al-Cr-Si sprayed metal coatings.
3. Claddings of Ni and Ni-Cr alloys.
4. Ni-Cr-B coatings applied by metal spraying or brazing.

These coatings vary considerably in their impact resistance, thermal shock behavior, ductility, erosion resistance, and ease of application, but all appear potentially capable of protecting at temperatures up to 2000 F. The Al-Cr-Si coatings appear promising for applications up to 2400 F, although they are less ductile than the clad or plated coatings. Rigorous control of all variables is required for satisfactory coatings.

A number of sheet-metal turbine nozzle vanes fabricated from Inconel clad 0.3% Cb-molybdenum alloy have been engine tested to evaluate oxidation resistance, thermal shock behavior, and erosion resistance with encouraging results. Over 30 hr of engine running was completed with only two vanes showing evidence of cladding failure. This was not serious and the vanes could have continued running. Test peak gas temperatures ran over 2000 F, with the average temperature at vane locations being about 1800 F.

In the thermal cycling test, with new vanes installed, no sign of failure was detected after the first 20 cycles, but after 40 cycles, equivalent to 10 hr of running time, four of the vanes showed cracking of the braze joining the trailing edge. Two of the cracked vanes were run 20 cycles more without excessive oxidation of the molybdenum base through the crack, indicating, for nozzle vanes at least, that catastrophic failure does not occur as soon as the flaw appears.

In the erosion test, the molybdenum vanes were located between superalloy vanes, but not directly in the area of maximum sand impingement. After injection of 4 pt of sand, the vanes were examined. The superalloy vanes, located in area of maximum sand impingement were severely eroded, the trailing edge being very thin, indicating a large loss in area. The molybdenum vanes in adjacent location were severely attacked, but coating failure did not occur. In some areas several mils of cladding were eroded away, but the coating was intact.

Although the outlook for developing higher strength alloys is quite encouraging, the problem of obtaining adequate oxidation resistance for 100 hr at temperatures in the range of 2500–2600 F is serious. The ductile metallic coatings seem to be limited to use below 2200 F. Multilayer coatings which contain a metallic layer to absorb impact and an oxide phase to provide oxidation resistance may offer some possibilities. For very-high-temperature short-time applications, or for use when mechanical shock is not a problem, the molybdenum disilicide coatings are attractive.

(Paper, "Molybdenum for Aircraft Applications" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

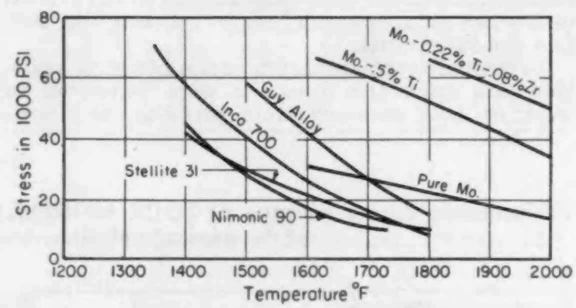



**Fig. 1—Molybdenum-base alloys show marked superiority over the best conventional nickel- and cobalt-base alloys in 100-hr stress-rupture properties.**

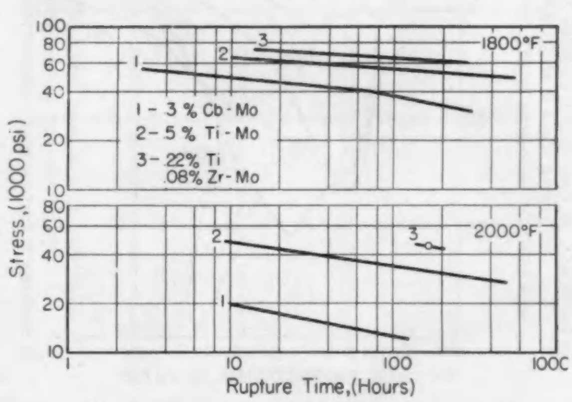



**Fig. 2—Creep-rupture properties of three arc-cast molybdenum-base alloys. The best combination of properties of the commercially available alloys is found in the molybdenum 0.5% Ti composition.**

# Car Engine Warmup Takes

## *Two recent researches show how and why*

MOST modern V-8 engines require a longer period of warmup than their predecessor in-line engines. The car manufacturer has felt safe in trading warmup performance, due to improved fuels, for other engine performance improvements which can be obtained with these more volatile fuels.

A comparison of engine warmup characteristics in which Standard Oil Co. (Indiana) and Ethyl Corp. cooperated led researchers to believe that the lower mixture temperatures prevailing in today's engines have made them more critical to the portion of the ASTM distillation curve between the 50% and the 90% points.

To compare warmup trends over a period of years, the data from this program were compared to warmup data obtained from previous tests conducted by these same laboratories. When the base fuel for this program, 193 F 50% point, was used as a standard, it was found that at 0 F the average 1956 car required 14 min and the best car required 9 min for warmup. In three previously conducted programs using 1946–47, 1949, and 1951–52 cars, the average warmup time was found to be approximately 10 min, 4½ min, and 9 min respectively.

Figs. 1, 2, 3, and 4 show results of a comparison of the warmup performance of 1956 model cars with earlier models of the same make.

Some makes have improved in warmup performance in recent years, some have remained about the same, and others have shown a definite reduction, according to these results. Since the engineering design factors which tend to improve warmup are

**Performance during warmup of FOUR MODELS of the same make of automobile in tests made by Standard Oil Co. (Indiana) and Ethyl Corp**

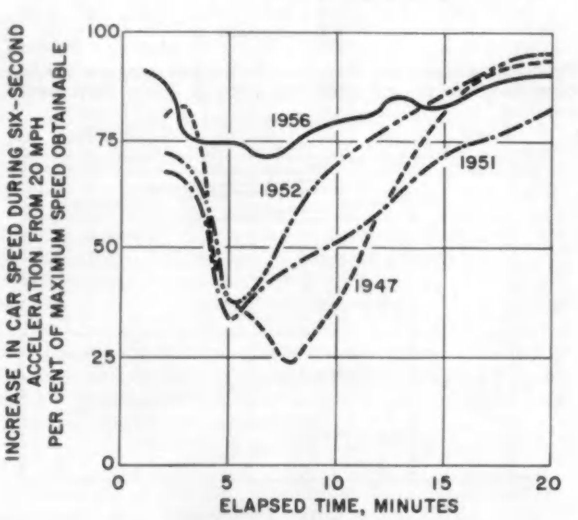



Fig. 1—All cars equipped with automatic transmission. Atmospheric temperature 0 F.

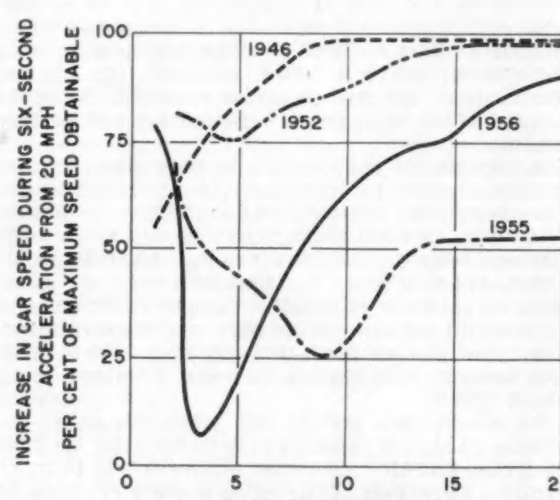



Fig. 2—All cars equipped with standard transmission. Atmospheric temperature 0 F. (1946 model run at 10 F.)

# Longer Than It Used To

## . . . *give specific examples.*

compromises which tend to reduce either fuel economy or lower the engine output of a warmed-up engine, these factors are weighed carefully by the designer. (Prominent among these factors are richer, full throttle carburetor mixtures; longer periods of choke operation; and more heat on the intake manifold.)

Data from Sun Oil Co. laboratories showing what has happened to warmup performance in recent years is revealed in Fig. 5. The same low volatility fuel was used throughout these tests. Results of tests of three car makes is shown. It is readily apparent that the warmup performance of Car A is considerably poorer than that of its predecessors which were equipped with 6-cyl, manual-choke engines. The performance of current Car B is also

**THIS ARTICLE is based on two papers presented at SAE Fuels and Lubricants Meeting:**

**"Effect of Fuel Volatility on Starting and Warmup of New Automobiles"**
by **G. T. Moore** and **R. D. Young,**
Standard Oil Co. (Indiana)
**H. A. Toulmin,** Ethyl Corp.

**"A Study of Cold-Starting and Warmup Performance of Some Recent Model Cars"**
by **W. P. Dugan,** Sun Oil Co.

(Both of these papers are available in full in multilith form from SAE Special Publications. Price: 35¢ each paper to members; 60¢ each paper to nonmembers.)

**Performance during warmup period of THREE MODELS**
**of the same make of automobile in tests made by Standard Oil Co. (Indiana) and Ethyl Corp.**

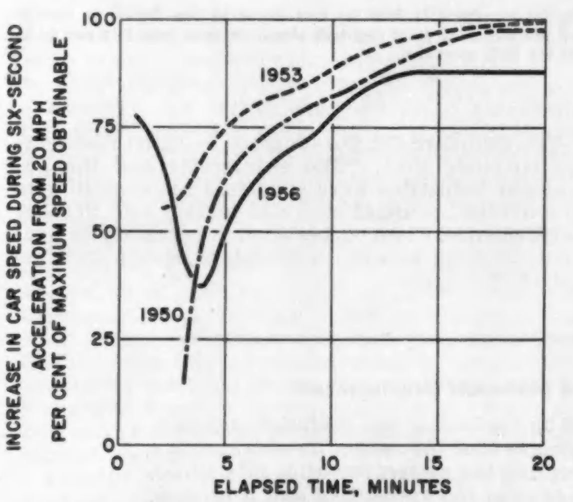



**Fig. 3—All cars equipped with automatic transmission. Atmospheric temperature 0 F.**

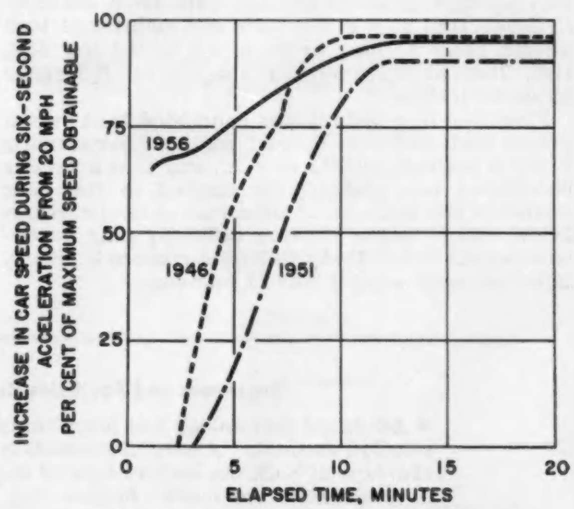



**Fig. 4—1951 and 1956 models equipped with automatic transmissions. 1946 model run at 10 F; 1951 and 1956 models run at 0 F.**

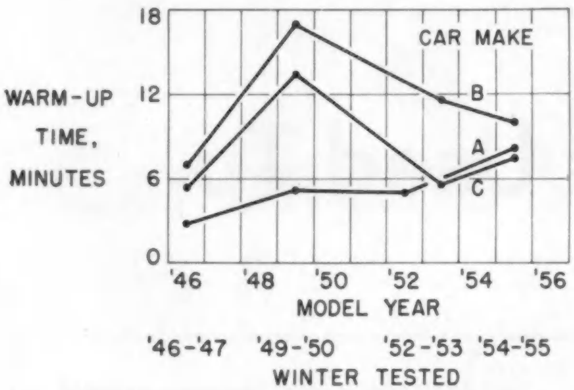



**Fig. 5—Tests (by Sun Oil) comparing warmup performance of older and newer models of the same make (using throughout the tests the low volatility fuel available when the earlier models came out) show that warmup performance is poorer on the later models.**

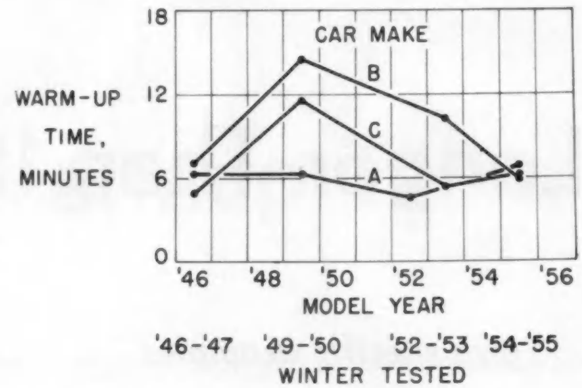



**Fig. 6—Estimated warmup times for the cars charted in Fig. 5, when operated on fuels available in the winter shown, indicate that** actual **warmup performance is** not **poorer.**

poorer than in 1946, although not as bad as the 1949 model. (1949 was the first automatic choke year.)

Fig. 6 shows that, despite the reduced performance with similar fuels, *actual* warmup performance is not poorer, because fuel volatility has increased times for these three cars when operated on the fuel over the years. Fig. 6 shows the estimated warmup times for these three cars when operated on the fuel available in the winter shown. The 1946 and 1955 data indicate that the automotive and petroleum industries have done a good job in tailoring warmup performance and fuel volatility.

In these Sun tests, there were some indications that 90% point did not affect warmup in some cars. Using two fuels designed to investigate this variable, it was finally concluded that, in addition to 50% point, 90% point also influences warmup in these cars.

This conclusion is based on the data presented in Fig. 7. This presents average data from six cars. It shows that at 0 F the high 90% point fuel took almost twice as long to warm up as the low 90% fuel. Even at 30 F, there was a significant difference in warmup time.

From the Sun tests it was concluded that "when proper fuels and oils are used, cold weather starting is not a problem in 1955 cars . . . and that a similar conclusion can probably be applied to the later models of the same cars." Also that at temperatures below −20 F "some starting difficulty may be encountered. But that starting performance is greatly improved over what it was 10 years ago."

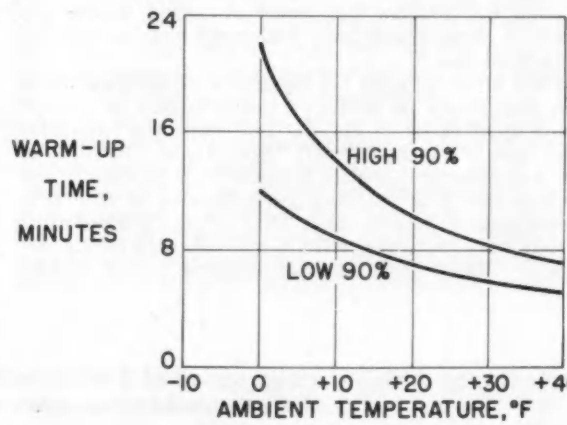



**Fig. 7—Average data from six cars tested by Sun Oil shows that at 0 F the high 90% point fuel took almost twice as long to warm up as the low 90% point fuel.**

The Standard Oil Co. (Indiana)—Ethyl researchers conclude that: "The automotive and the petroleum industries have a mutual responsibility to provide the customer with satisfactory cold weather performance. Close cooperation is necessary to prevent conflicts between automotive design and fuel volatility trends.

**Engineers and Facilities Retard Materials Development**

■ *Advanced technology has been hampered by the lack of new materials and fabrication methods. A careful evaluation indicates that the reason for this lack is a shortage of both the correct type of engineer and the correct facilities with which to do development work. Engineering has become too specialized and a broader knowledge of material problems is necessary to accomplish real advancement.*

—Dr. H. Hausner

# Steel and Titanium Extrusions

## Today:

## Increasing in Demand

## Tomorrow:

## Unusual Shapes

Based on paper by **F. T. Roberts, Jr.,** Northrop Aircraft, Inc.

ELEVATED temperatures and space limitations have accelerated the use of titanium and steel-alloy extrusions for structural application in air-frame design. The future, however, holds greater opportunities for extrusions, with shapes which are now considered impossible or impractical likely to become a reality.

Titanium and steel alloys today are being extruded on a production basis for production airplanes. For example, over 100,000 lb of alloy 4340 steel has been extruded in one plant for the Lockheed C130 transport plane alone. Over 50,000 lb has been extruded for the Northrop F-89. Titanium-alloy extrusions are found in the McDonnell F-101, in North American missiles, and in other airframes.

Recently, the Heavy Press Program has opened new fields, particularly in the circle size of configuration, the length, and the overall weight of extruded sections. As expected, these presses, as they come into being are reaching full capacity of their production capabilities.

In general, the configuration for production parts are angles, H's, tees, and similar simple design. More difficult configurations are produced on a development basis. Section thickness desired is 0.188 in. minimum, although work has been done below 0.125 in. with more or less encouraging results. The tolerances extruded to are roughly twice those for aluminum alloys, in section dimensions. Twist and bow can be controlled to approximately that of aluminum specifications.

Lengths have been extruded successfully up to 20 ft in both titanium and steel alloys. Shorter lengths are preferred because contact with the die surface should be kept to a minimum to minimize tool overheating by the hot flowing metal. The greater the length, the greater the incidence for surface defects to spoil the section.

The area of cross-section and the gross weight of a section that can be produced is a function of length of section and the pounds of available metal in the billet. Front and rear-end scrap, as well as the butt discard, must be taken into consideration.

The mechanical properties of both titanium and steel extrusions are excellent. Longitudinal prop-

**Serving on the panel which discussed aluminum, steel, and titanium extrusions were:**

**J. A. Van Hamersveld, panel leader**
Northrop Aircraft, Inc.

**E. A. Green, panel co-leader**
Lockheed Aircraft Corp.

**F. T. Roberts, Jr., panel secretary**
Northrop Aircraft, Inc.

**C. J. Huffman**
Kaiser Aluminum and Chemical Corp.

**K. B. Guiney**
Aluminum Co. of America

**G. A. Moudry**
Harvey Machine Co., Inc.

**F. C. Hoffman**
Lockheed Aircraft Corp.

erties are at least as good as other wrought materials. The characteristic extrusion effect encountered in aluminum alloys and resulting in enhanced tensile and yield strengths in the extrusion direction is not observed with titanium and steel. Consequently, the properties are not nearly as dependent on specimen orientation.

Surfaces of titanium and steel extrusions are not as good as aluminum and similar configurations cannot be obtained.

Most of the common and exploratory alloys of steel and titanium have been extruded successfully. The higher-alloyed materials provide more difficulty and will necessitate further research to establish the optimum fabricating practices. For example, the titanium alloy 7 Al-3 Mo has been extruded successfully into a number of shapes. However, because of its strength at elevated temperatures, it is necessary to extrude at a temperature above the beta transus when using normal maximum extrusion pressure to obtain extrusion of metal into sections of low-cross-section area. Optimum mechanical properties cannot be obtained with this increased extrusion temperature.

Increased mechanical properties appear probable, particularly in titanium alloys. For example, one section in the titanium-aluminum-molybdenum series, in a heat-treated, water-quenched, and aged condition exhibited tensile properties in the longitudinal direction of 208,200 psi ultimate, 183,800 psi yield, and 10.6% elongation in a four times diameter gage length. On a competitive strength-weight-ratio basis, it would be necessary to achieve an ultimate strength in an aluminum alloy of 133,000 psi. By today's standards, this is impossible. On the same basis, to be competitive on a strength-weight ratio, it would be necessary for steel to have an ultimate strength of 380,000 psi.

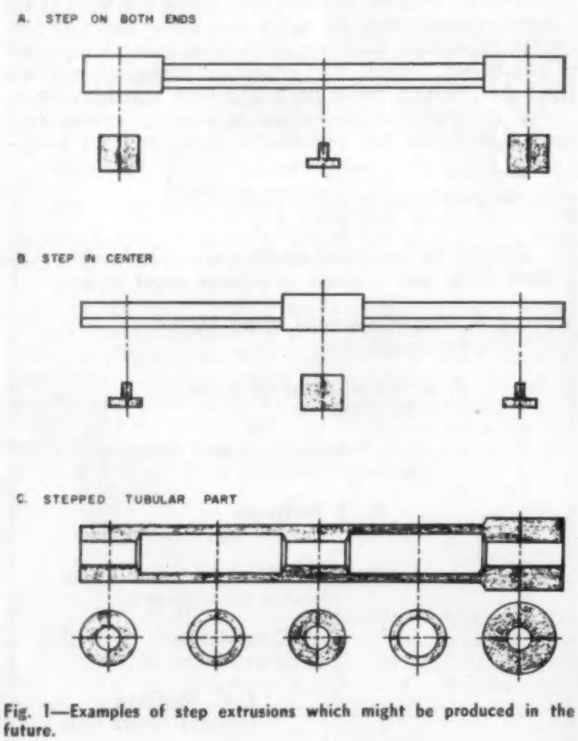


Fig. 1—Examples of step extrusions which might be produced in the future.

Work has been done on cold and hot drawing of alloy-steel extruded sections. This serves to provide closer tolerances and an improved surface. Satisfactory sections have been produced and development work now in progress by a number of steel extruders should result in placing this on a production basis. Titanium alloys offer much more resistance to drawing. Considerable development work will be necessary before drawn titanium-alloy shapes can be offered for production.

The present goal is to produce the desired alloys in shapes having a surface condition that requires no machining operation. This has been accomplished on a development basis. But larger and longer shapes will be requested in quantity in the near future. To anticipate this, efforts are being made to procure and make available the specialized extrusion and finishing equipment necessary for the production of these parts for present "paper" airplanes.

## Unusual Shapes May Highlight Future Extrusions

Extrusion technology has advanced very rapidly in the past several years, making it difficult to predict lines of future growth. The present day producer many times finds himself producing products which a few years ago may have been considered impossible or impractical. Future extrusions may be even more surprising.

A possible step extrusion which might be produced in the future would be an extrusion with a major section on both ends, such as shown in Fig. 1A. This would allow an integral fitting to be used on both extremities of the part. With the advancement of extrusion technology, this shape appears a possibility and may become commonplace in the future.

Many of the present step extrusions are used for aircraft-spar-cap application. Requirements for step extrusions can be visualized with the major portion being located in the center of the part as shown in Fig. 1B. It would seem that extrusions of this type could be ideally used for aircraft-stabilizer-spar caps extending completely through the fuselage or for similar applications on the wing. In some cases this enlarged portion could be used for attachment points for the landing gear. While seemingly far-fetched, these products are not impossible from the extrusion producers' standpoint although a great deal of time and development effort would be required to make these products a production reality.

Many applications for large tubular parts are being developed in the missile field. Internal and external steps on these tubes can be obtained through the use of a stepped mandrel combined with the techniques normally used to produce step extrusions. The use of a stepped mandrel has previously had the limitations of allowing only unidirectional stepping of the interior surface. With modern extrusion equipment it is possible to place these steps at either end of the tube or in the center, as desired. Typical of the product that could be produced by this means is the part shown in Fig. 1C.

In other areas of development of extruded prod-

ucts for aircraft usage, integrally stiffened panels are now becoming commonplace. These products are presently available in widths up to 25 in. extruded in flat configuration. Development work indicates greater widths are available from existing equipment. Frequently this type of section will be extruded in a "V" or tubular configuration to obtain greater widths. Much effort has been expended in attempting to flatten tubular extrusions to obtain the desired flatness required of aerodynamic surfaces. The success of this work has been limited, hence, the uses of this product have been principally in interior applications. With the amount of development effort being expended in this area, it seems very likely the problem of flattening tubular extrusions will soon become a thing of the past.

Looking to the future on the uses of extrusions in the aircraft industry, it seems that a new family of products will be produced within the next few years. With the full scale production from the Heavy Press Program, very likely larger and longer extrusions will be commonplace. With the new demands industry is placing on the extrusion process it is assured of continued growth into bigger and wider fields of application.

(Secretary's report of production panel "Extrusions—Aluminum, Steel, and Titanium" on which this abridgment is based, is available along with 13 other panel reports as SP-317 from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: $2 to members; $4 to nonmembers.)

# Ford Expects the Edsel . . .

## . . . to get sales generated by shifts within the market. . . . The market is changing.

Based on paper by **J. Emmet Judge,** Edsel Division, Ford Motor Co.

ABOUT 40% of new car sales represent shifts from one price range to another and from one product to another.

Consumer loyalty to company products ranges all the way from a low of 46% to a high of 67% and the average is 60%. When the owner of one make buys another car, the chances are 2.5/1 that he will buy another make produced by the same company. One-fifth of all low-price car owners who purchase new cars trade up each year, reflecting their higher incomes and the overall gain in prosperity.

It stands to reason that the company with three products in the medium-price field is equipped to retain more than 75% of the owners moving out of the low-price field. While Ford, with only one make in the medium-price field, can hope to hold only 25% of its graduating owners.

The pattern of the market is dictated to some extent by the principal companies and the manner in which they place their products on the market. Ford is predominantly a producer in the low-price field. 80% of volume is in the Ford car. General Motors distributes about 50% of its volume in the low-price field and 50% in the medium and high. Actually, the predominance of volume was in the upper area of the market in 1955. A similar pattern holds for Chrysler with its three makes in the medium-high market.

In planning the Edsel, we began with the market and we have never lost sight of it.

Ford plans an initial Edsel dealer organization of 1200 franchises. This will ultimately grow to 2500–3000.

The basic engineering begins with physical dimensions. Then comes styling, followed by the engineering which gives the proper "feel." The owner judges this when he sits behind the wheel. His final rating largely measures the type of engineering which has gone into the automobile.

At Ford we put maximum emphasis on control of costs.

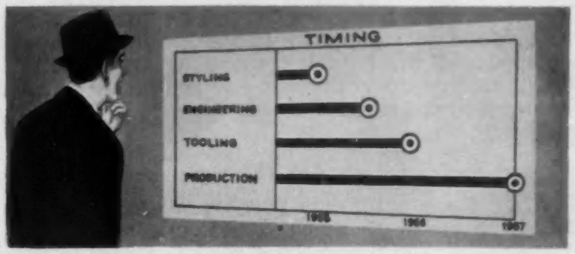



Fig. 1—Styling, engineering, tooling, and production operations all require considerable time in the development of a new car.

Weight objectives are set along with cost objectives. While you cannot control costs alone by controlling weight, weight does heavily influence the total economies of design. As steel and glass are added to a vehicle costs increase. So weights are controlled and that control is reflected in costs.

The American car buying public attaches great importance to innovation features. Call them gadgets, they are still important. We are constantly searching for new ones and this has been an important part of the Edsel program.

It takes almost three years to get a new car before the public once some of the basic package considerations have been laid down. (See Fig. 1.) It takes almost two years from the time styling is under way until the car appears in dealer showrooms. Engineering, styling, purchasing, and tooling operations require considerable time. To minimize overall requirements, they must be phased and overlapped to reach the overall objective in a minimum of time.

The fall 1957 introductory date for the Edsel was set many months ago and that date will be met by good planning.

(Paper, "Planning a New Automobile" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# How Nebraska Tests Tractors

**During the past 36 years of testing 570 tractor models, the University of Nebraska Tractor Tests have established a reputation for integrity and thoroughness that influences tractor buying far beyond state boundaries.**

Based on paper by **L. F. Larsen,** University of Nebraska

SINCE 1919 a stock tractor of each model sold in Nebraska has been tested by the University of Nebraska to make sure its performance lives up to its manufacturer's claims. If it does, and if the manufacturer maintains service stations with full supply of replacement parts for each model within reasonable shipping distance of customers, the State Railway Commission grants a permit for its sale in Nebraska.

Manufacturers are currently being charged a test fee of $500 plus $25 for each horsepower of the engine. Tractors presented for testing must be stock models and not equipped with any special appliances or apparatus not regularly supplied. Once the test starts neither specifications nor equipment can be changed by the manufacturer.

### Tests Are Thorough

After the tractor has been "limbered-up" it is belted to an electric dynamometer to determine belt horsepower. The top radiator tank is drilled to take an indicating thermometer, a fuel line is installed from the tractor fuel system to the fuel-weighing equipment, and a tachometer drive is attached to the crankshaft.

Formerly belt slippage was determined by measuring the belt thickness and the circumference of both pulleys to obtain the effective circumference of each. Beginning with 1956, however, belt slippage has been determined by obtaining the rpm of each pulley at no load.

At 10 min intervals readings are taken of the engine crankshaft and brake speed, load on scale beam of dynamometer, temperature of water in top tank of radiator, air temperature (wet and dry bulb at a point about 5 ft in front of the radiator), and pounds of fuel used. Barometer readings are taken every hour.

Engine is then run at full load until it is thoroughly warmed up and operating at constant temperature. Adjustments are made to get maximum output at the number of rpm recommended by the manufacturer for normal operation. This "100% maximum" belt test is run for 2 hr to check or establish belt horsepower ratings.

If the manufacturer wishes to use a carburetor adjustment leaner than the 100% setting, a series of trial runs of 20 to 30 min at leaner settings are made and the manufacturer's representative is permitted to chose from these a "most practical operating setting." This operating setting of the carburetor is used throughout the remainder of the test (except for the 100% maximum drawbar test in rated gear used to determine the drawbar rating).

By this means inspectors determine the maximum

Continued on page 82

## SAE Methods Used

**NEBRASKA TESTS use same method of determining belt and drawbar ratings as in the SAE Tractor Test Code.**

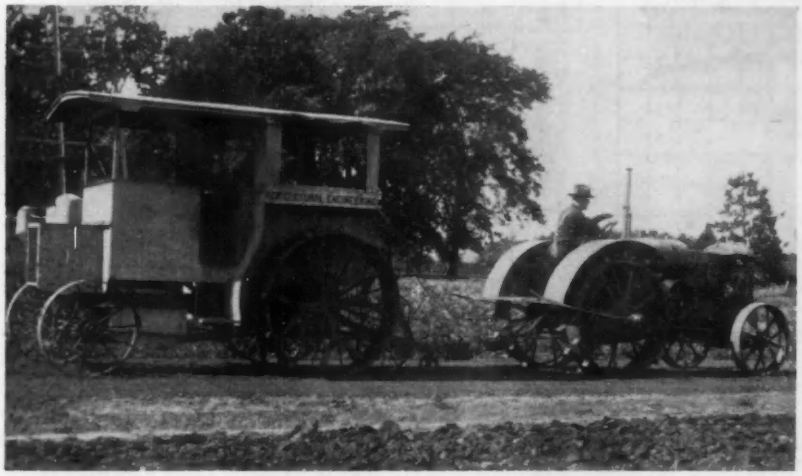
**These ratings are somewhat less than the maximum horsepower output of the tractor so that there is a reserve for emergencies.**

**Belt horsepower is 85% of maximum corrected horsepower obtained by correcting the observed test horsepower to standard conditions (60 F and 29.92 in. Hg.).**

**Drawbar horsepower rating is 75% of maximum corrected horsepower obtained by correcting observed test horsepower to standard conditions.**

THE NEW CONCRETE TEST COURSE which is surrounded by an earthen test course for crawler tractors. Part of the turn is banked for safety during runs up to 20 mph.

**A NEW HARD SURFACED** concrete test course, completed in May, 1956, is used for all wheel tractors. This and larger earthen course for the crawler type tractors promise more uniform and comparative test results than ever before possible.



## Old

FIRST TEST CAR and load unit used by University of Nebraska Department of Agricultural Engineering under 1919 Tractor Test Law.

## New

PRESENT TEST CAR was first used in 1940. This shows the first lpg tractor tested in 1949. A new 10 sq-in. hydraulic cylinder is used to measure drawbar pull.

# Troubles with

# RESIDUAL FUELS in

**4-CYCLE,** medium-speed engines when tested, yielded the following indications from the short-term performance data secured:

**1.** THERMAL EFFICIENCY with ASTM No. 6 residual fuel is comparable at high load to that observed while operating on ASTM No. 2 distillate fuel. However, the termal efficiency becomes progressively poorer as the engine load is decreased, as shown in Fig. 1 below.

**2.** EXHAUST SMOKING with ASTM No. 6 fuel above 25% load factor was comparable to that observed with distillate fuel. Below 25% load factor, the smoke meter trace changed from black to brown, indicating that unburned fuel was being emitted from the exhaust stacks (Fig. 2).

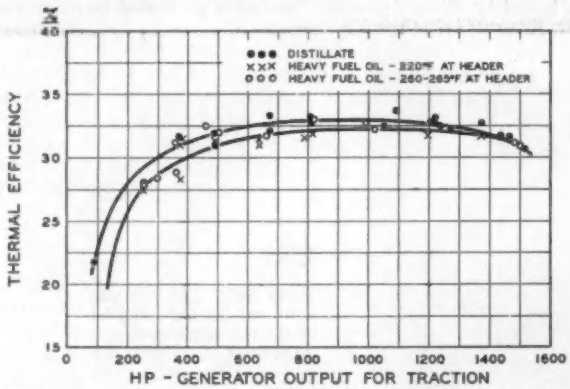



Fig. 1—Relation between thermal efficiency and generator output for traction (4-stroke engine).

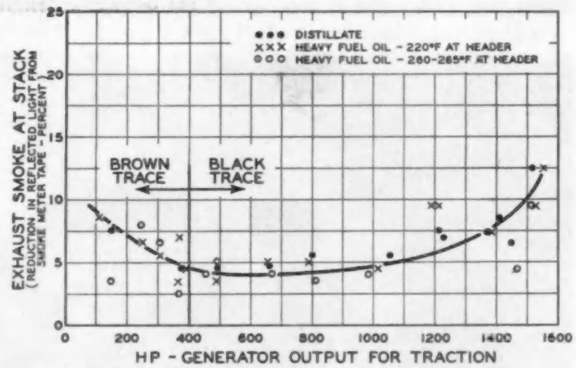



Fig. 2—Relation between per cent exhaust smoke and generator output for traction (4-stroke engine).

**3.** PEAK CYLINDER PRESSURES and exhaust temperatures while operating on ASTM No. 6 fuel compared favorably with those obtained while running on distillate diesel fuel. (See Figs. 3 and 4 below.)

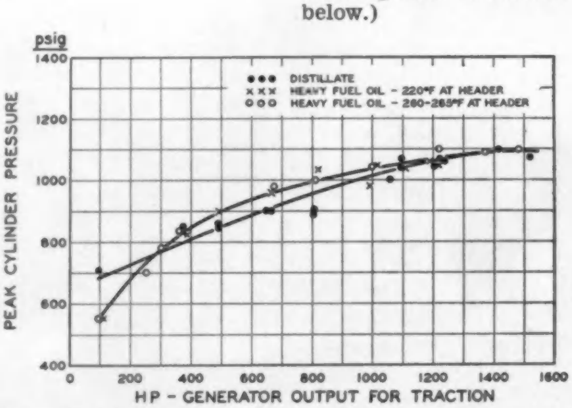



Fig. 3—Relation between peak cylinder pressure and generator output for traction (4-stroke engine).

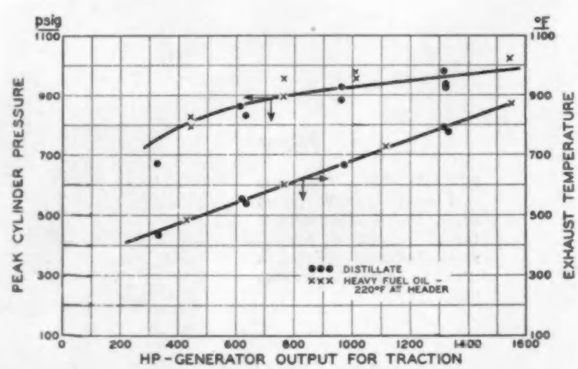



Fig. 4—Relation between peak cylinder pressure and exhaust temperature and generator output for traction (4-stroke engine).

# Medium-Speed Diesels

Excerpts from paper by **G. L. Neely, E. F. Griep, P. L. Pinotti,** Standard Oil Co. of California

**4.** IGNITION DELAY, measured electronically, while using the ASTM No. 6 fuel, was greater throughout the entire load range than while using ASTM No. 2 fuel. The maximum difference in ignition delay occurred at approximately 25% load factor (Fig. 5).

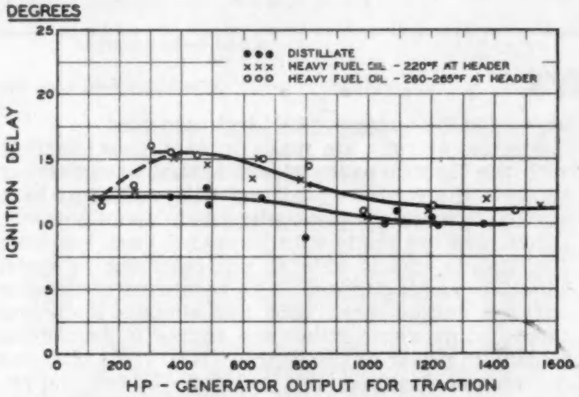



Fig. 5—Relation between ignition delay and generator output for traction (4-stroke engine).

**5.** INCREASING THE TEMPERATURE of the fuel to the injectors above 220 F had no apparent effect on engine performance as measured by these tests.

**2-STROKE**, medium-speed engines, when tested, yielded an indication that the engine is more tolerant to the ASTM No. 6 fuel at high load factor than at intermediate or light loads.

Data obtained indicate that at higher loads this engine will satisfactorily deliver its power with a 1000 SSU at 100 F blend of ASTM No. 6 and ASTM No. 2 fuel. However, as the load on the engine is reduced, the tolerance of the engine for ASTM No. 6 fuel is also reduced.

This is illustrated in Fig. 6 where it may be observed that the thermal efficiency observed at higher loads with the 940 SSU at 100 F blend of the ASTM No. 2 and No. 6 fuels compared favorably with that observed with the ASTM No. 2 fuel. But, as the load on the engine is reduced, the percentage of the ASTM No. 6 that can be utilized, with thermal efficiency comparable with that of the ASTM No. 2, is reduced.

**MEDIUM-speed diesel engines, as presently designed, cannot be operated satisfactorily on residual fuels only, over the full load range. Testing covering a period of years has shown no single reversal of this finding regardless of the engine or the residual fuel used.**

**THERMAL efficiency decreases with decreasing load, if the viscosity of the residual fuels exceeds certain maximum limitations. Furthermore, use of residual fuels under idle and light load conditions may result in markedly increased wear—particularly when the piston rings are cast iron.**

**EVEN helps such as high injection pressures, higher jacket temperatures, and multiple injectors or air injection do not bring completely satisfactory operation of these medium high-speed engines on residual fuels alone.**

### Two-Fuel System Indicated

Data obtained indicate that (1) without changes in engine design, a two-fuel system is necessary for satisfactory operation of current railroad diesel engines using residual fuels, and (2) the fuel injector is the engine component that is most critical operationally when using residual fuels.

It is not known whether or not injectors can be made that will permit use of heavy residual fuels at idle operation which will also be suitable for full load operation. But, even if such an injector could be built to operate an engine of current design on residual fuel of only 300 SSU at 100 F, a two-fuel system would probably provide further economies. Also distillate fuel is desirable for other reasons, including purging of lines when shutting down and for starting and warming up periods.

Certain desirable basic requirements for a satis-

factory two-fuel system arise from further analysis of the test data accumulated. These are:

(a) Residual fuels used should preferably be run-of-the-mill, heavy commercial grades rather than specialized formulations.

(b) The heaviest residual fuel and the minimum amount of added distillate fuel consistent with satisfactory engine operation should be supplied to the engine at each particular load condition.

(c) There should be no requirement that the residual fuels be full compatible with the distillate fuel used.

(d) Increased maintenance costs due to the use of residual fuels should be minimized.

### Engine Deposits Up

Engine deposits, operating with residual fuel blends and a two-fuel system, compare favorably with those observed with distillate fuel operation. But when operating with residual fuels alone, engine wear with conventional cast iron liners and cast iron rings was found to be two to three times higher than normal with distillate fuels in 12 months of typical railroad service.

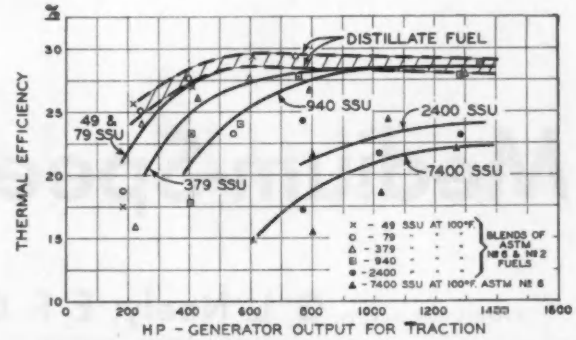



Fig. 6—Relation between thermal efficiency and generator output for traction for various blends of ASTM No. 6 and No. 2 fuels (2-stroke engine).

(Paper on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ to members; 60¢ to nonmembers.)

## How Nebraska Tests Tractors . . . .

(Continued from page 78)

power developed and the fuel consumption with a carburetor setting that the manufacturer says is practical for field operations.

Another test determines whether the tractor will carry its rated load on the belt and records fuel consumption and other operating data.

A third test shows fuel consumption and governor control of the engine speed when the load is varied.

Torque at the dynamometer is measured as the engine is lugged below rated speed. The Revised 1956 Test Code calls for determining per cent torque at rated speed and per cent of rated engine speed.

### Drawbar Tests

The manufacturer's representative is allowed to install and select the tires and wheels to be used during drawbar tests, but they must use standard equipment regularly offered for sale in Nebraska.

After the effective circumferences of the drive wheels are determined by experiment, the tractor is hitched to an instrument car and loading units through an hydraulic draft unit. Several drawbar runs over a measured distance of 500 ft are made with relatively constant load, normal operating temperatures, and engine speed close to that specified by the manufacturer.

The first drawbar test determines maximum horsepower by using the 100% carburetor setting as found on the belt. Test is made in one gear (the "rated" gear which the manufacturer says is most suitable for plowing or ordinary farm work). The observed 100% maximum drawbar horsepower is corrected to standard conditions (60 F and 29.92 in. Hg) and multiplied by 0.75 to get "calculated rating."

To determine the maximum horsepower that the tractor will develop in each forward gear with engine running at rated speed, the same settings selected for the operating belt tests are used.

A series of runs are made in each gear starting with the throttle partly closed so that the governor controls the engine speed and with sufficient load applied to make the drive wheels slip about 5 or 6%. Other runs are made with increased load, but with the throttle opened wider to give rated engine speed which increases slippage. The balancing of throttle opening, engine speed, load, and slippage is carried to the point where either the engine is developing maximum power or the slippage is so great that the horsepower is appreciably reduced. Usually no results are used when the slippage exceeds 16%. Horsepower is calculated for each of the 500 ft runs. The runs producing the largest amount of power, and at the same time keeping within 1% of rated engine speed, are averaged and recorded as the operating maximum drawbar horsepower in that gear.

A 10-hour test is made to determine whether the tractor can pull its rated load continuously and to get a record of fuel consumption during drawbar work. Carburetor is set for "operating" and the gear used is that recommended for plowing and ordinary farm work.

At the same time calculations are made for the drawbar pull in pounds, the rate of travel in feet per minute, and the per cent of drive wheel slippage.

After the above and other drawbar tests are completed, the tractor is disassembled and inspected for wear of parts such as valves, spark plugs, breaker points, pistons, bearings, and fuel, oil, and water connections. The amount of and condition of lubricating oil used throughout the test is calculated.

(Paper, "Nebraska Tractor Test Changes," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# Lab Durability Tests Help Make Better Diesels

THE development of reliable light-weight diesel engines depends in part on the use of a variety of cost- and time-saving laboratory durability tests. We will discuss here a few of the ones that have been found to give results that correlate well with field experience. We will cover:

1. Accelerated tests.
2. Cycling tests.
3. Small-scale dynamic strain-gage tests.
4. Sparrow aggravation test.

## Accelerated Tests

Accelerated tests, in which failures are obtained by testing under conditions more severe than in the field, should be used wherever possible to obtain results quickly.

The method of accelerating the test may vary. In some cases it may actually involve the use of test conditions impossible to achieve under field operation. The accelerating test can also be combined with others, such as fatigue and cycling tests.

The development of the bearing for the fuel gear pump shown in Fig. 1 is a typical example of accelerated test procedure. The bearings of the pump needed increased durability for this particular application. The pump discharge pressure does not exceed 300 psi, so an accelerated bearing test was designed using 500-psi overload pressure to hasten bearing failure. The pump test was also designed to use mineral spirits which has practically no lubricating value compared with fuel oil. In addition, the gear pump was run at 250 F. Using an accelerated bench test far exceeding known field conditions, gear pumps were run to destruction with the following shaft and bearing combinations:

1. Steel journal and cast-iron bearing—35 min (average).
2. Cast-iron journal and cast-iron bearing—210 hr (average).
3. Steel journal and small-diameter needle bearing—430 hr (average).
4. Steel journal and large-diameter needle bearing—1550 hr (average).

The results of the tests presented a clearcut difference in the combinations. The test reproduced

**This story is based on the following papers:**

"Choosing the Right Test," by **R. C. Schmidt,** Cummins Engine Co., Inc.

"Dynamic Strain-Gage Testing of Critical Engine Parts," by **W. C. Arnold,** Fairbanks, Morse, & Co.

"Naval Laboratory Tests of Diesel Engines Simulating Fleet Operating Conditions," by **Sherod L. Earle,** U. S. Naval Engineering Experiment Station

"Cyclic Testing to Simulate Diesel-Engine Service Conditions," by **Roger D. Wellington,** Detroit Diesel-Engine Division, GMC

"Determination of the Unknowns in Correlation of Laboratory and Customer Tests Results," by **M. C. Gillispie and L. A. Grotto,** International Harvester Co.

**Discussion of these papers by:**

**M. R. Bennett,** International Harvester Co.

**Thomas Reeves,** Continental Motors Corp.

**Secretary's report of oral discussion by:**

**W. J. Lux,** Caterpillar Tractor Co.

Each of these papers (not the discussions) is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ each paper to members; 60¢ each paper to nonmembers.

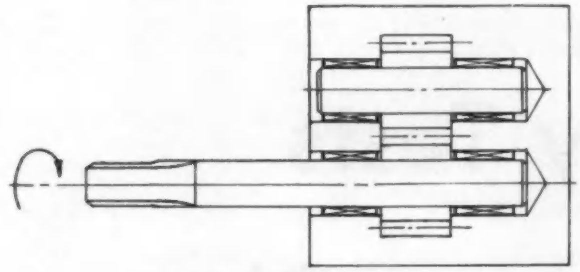


Fig. 1—Fuel oil gear pump.

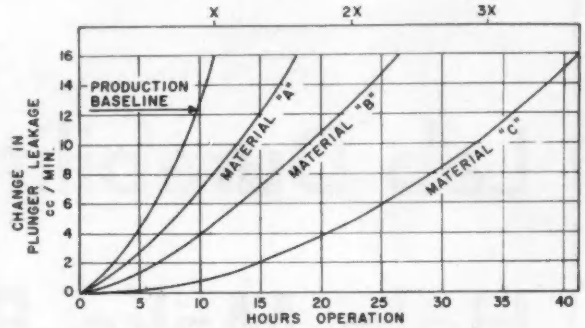



Fig. 2—Results of accelerated plunger wear test.

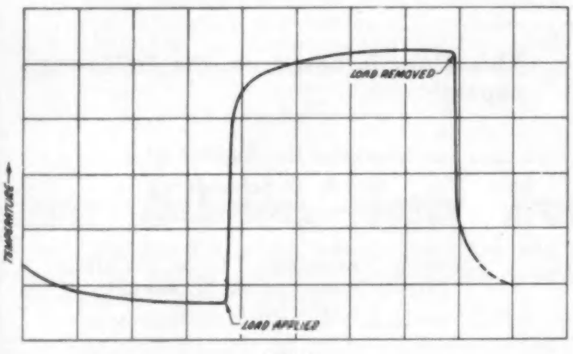



Fig. 3—Cylinder-head fire deck temperature changes—temperature varies from 175 F to 625 F during 20-min cycle.

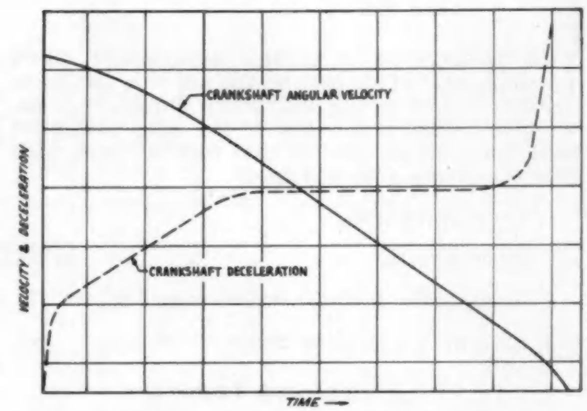



Fig. 4—Analysis of stall cycle. Engine is stalled by railroad car brake. Curves show instantaneous velocities and character of deceleration curve.

failures of field trial parts in a much shorter time. The best combination found subsequently proved to have satisfactory life in the field, exceeding the accelerated test life by thousands of hours.

Another technique of accelerating the test can be illustrated by the story of wear failures in an injection pumps.

Field experience with certain production injection pumps indicated that premature adjustment of the pump was needed to maintain engine power in a high percentage of the pumps. Investigation of the reason for this adjustment requirement revealed the cause to be abrasive wear of the metering section of the injection pump plunger and bushing unit. Wear in this area was caused by contaminants in the fuel that were not removed by the filtering system. Since revisions in the filtering system to trap this relatively small amount of material did not seem to be practically applicable, the alternative of a increased wear resistance of the plunger-bushing material combination was selected. Since the number of possible material combinations was large, a brief test was desired to evaluate these materials in resistance to abrasive wear in comparison to the production material, which had a well-known field performance life.

A test setup was devised to circulate abrasive-dust contaminated fuel through two plungers of an injection pump.

The test material was always installed in one of the plungers and a standard production plunger in the other for control and comparison. Reversing of the test and production material location was done often enough to assure that plunger location did not affect test results. Wear was measured by the standard plunger leakage test specified for the injection equipment. Experience has proved that an increase in leakage rate under conditions of this test is a direct function of wear of the mating parts.

Results of four of these tests are shown in Fig. 2. On the basis of these results a pre-production lot of the best material combination was made up. Production costs of this material proved to be far above the predicted level, due to an unexpected high tool mortality. Consequently, a similar lot of the second best material from a wear resistance standpoint was made up on the production tooling. Costs of this material were in line with the predicted life improvement.

These two lots of plunger-bushing combinations were released for testing in field test facilities and selected customer applications. Results of these tests showed a satisfactory correlation in life increase with the results of the laboratory accelerated

test. In consideration of all the factors, including manufacturing cost, the second material in the order of durability was chosen for use in production. Experience in several thousand injection pumps has further substantiated the results of the accelerated laboratory tests.

## Cycling Tests

Cycling testing introduces large thermal variations, structural loadings, and certain acceleration loadings that do not exist in constant-speed full-load testing of engines.

The design of a cyclic test may be the simple procedure of observing an operation in the field, setting down the elements thought to be important to the difficulty, and specifying a mode of operation of the engine which will emphasize these important elements. On the other hand, considerable effort may be expended in measuring in the field the conditions of load and speed of a typical engine installation. With the understanding thus gained, a cycle can be designed to accelerate the solution of the problem.

One complete cycle may take only a few minutes, or it may take as long as 24 hr. The shorter cycles are used to test diesel engines used in ground vehicles. Since such short periods would not be appropriate for large marine diesels, the U. S. Naval Engineering Experiment Station has developed longer versions to permit more realistic testing of diesels designed for Naval use.

Among the short time cycles are the:

1. 10-10 cycle.
2. Coffee-stop cycle.
3. Railroad brake cycle.

The 10-10 cycle is used to subject engine fire box parts to as many severe changes in temperature as possible in a given time.

Fig. 3 shows the temperature variation experienced on the fire deck of a cylinder head when the engine is run on a 10-min cycle. During 10 min of idle time at 500 rpm, the temperature approaches a low of 175 F. Within one-half minute after the application of some 10% overload the temperature is over 500 F and reaches 625 F by the end of the 10-min load period. Upon reduction of the load, the temperature falls rapidly below 250 F to complete the cycle. Piston temperatures are found to vary with load even more rapidly and it seems that a piston temperature cycle could be accomplished in one minute of load followed by two or three minutes of idle.

For this cycle a heat exchanger cooled engine is connected to an eddy-current dynamometer. The engine is equipped with oversize fuel injectors and the governor is set about 10% overspeed. The thermostat is removed from the engine to allow the water to cool down during the idle portion of the cycle. The heat exchanger raw water is supplied from the laboratory system and flows full at all times. The engine is loaded for 10 min, then the dynamometer field is interrupted and simultaneously air is admitted to a cylinder, which resets the governor to idle speed. After 10 min of idle, the field is energized and the governor is returned to its full-speed setting.

With this cycle, cylinder heads are cracked in two-thirds of the time required at the same loading at constant speed. An experimental exhaust valve showed the following experience. On a full-load constant-speed test, one of 24 valves failed in 1500 hrs, or 4% failure. On the 10-10 cycle, 16 of 72 valves failed, or 22%, in the same elapsed time and only half of that time was at full load.

The coffee-stop cycle is a good example of a cycle designed from field observation. After a stop for coffee, a truck driver gets in his cab and starts to roll. Perhaps the thermal shock under such conditions is even higher than when an engine is kept running between load periods. After a 15-min period of full load with engine water controlled at 180 F, the engine is stopped. Five minutes later an auxiliary water pump starts and pumps cold water through the engine for 10 min, following which the engine is started and returned to full load.

This cycle has been revised to give 20 cycles per hr rather than two. After 1½ min of full load the engine is stopped. An auxiliary pump continues to pump cold water through the engine for another 1½ min, at which time the engine is again started and immediately put on full load. On this cycle a high-output engine developed cylinder-head cracks in 98 elapsed test hr. The same engine at constant speed developed no cracks in 343 hr. New cylinder heads were used in both tests.

For a period of time this cycle did not produce and its failure was traced to a subtle change. Because of occasional engine stalling, the dynamometer load was not being applied until the engine had reached governed speed. This relieved the engine of the period of acceleration under load and the cycle became considerably less effective.

The railroad cycle is an attempt to obtain cyclic loading on engine parts by sudden changes of engine speed. A large disc brake developed for light-weight railroad trains is used to bring a running engine to a sudden stop. The brake is coupled directly to the engine under test and supported on a pedestal bear-

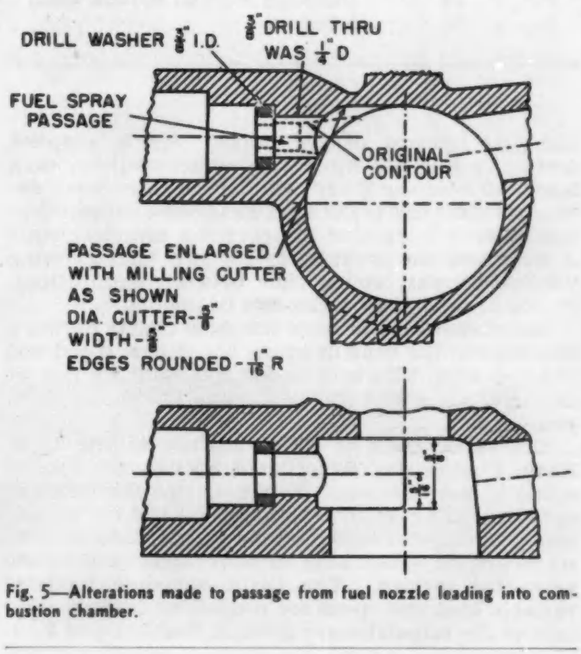



**Fig. 5—Alterations made to passage from fuel nozzle leading into combustion chamber.**

**Table 1—Variable-Speed Endurance Cycle—Propulsion Service**

(One cycle consists of 24 hr of operation)

| Hr | Min | Load and Speed |
|---|---|---|
| 2 | 0 | Rated load and speed |
| 1 | 0 | 85% load and 90% speed |
| 0 | 15 | 20% load and 55% speed |
| 2 | 0 | Rated load and speed |
| 0 | 15 | 40% load and 70% speed |
| 2 | 0 | 85% load and rated speed[a] |
| 0 | 15 | 40% load and 70% speed |
| 2 | 0 | Maximum overload and rated speed |
| 1 | 50 | 50% load and 75% speed |
| 2 | 0 | Rated load and speed |
| 2 | 0 | 60% load and 80% speed |
| 2 | 0 | Rated load and speed |
| 0 | 15 | 20% load and 55% speed |
| 2 | 30 | 70% load and 85% speed |
| 1 | 0 | 40% load and 70% speed |
| 2 | 0 | Rated load and speed |
| 1 | 0 | 50% load and 75% speed |
| 0 | 30 | Shutdown |

[a] Direct reversing engines operated in reverse drive during this period.

**Table 2—Constant-Speed Endurance Cycle—Generator Service**

(One cycle consists of 8 hr of operation)

| Hr | Min | Load and Speed |
|---|---|---|
| 2 | 0 | Rated load and rated speed |
| 1 | 0 | 85% load and rated speed |
| 0 | 10 | No load and idling speed |
| 1 | 50 | Rated load and speed |
| 0 | 10 | No load and idling speed |
| 0 | 30 | 85% load and rated speed |
| 0 | 10 | No load and idling speed |
| 0 | 10 | 85% load and rated speed |
| 1 | 50 | Maximum overload at rated speed |
| 0 | 10 | Shutdown |

ing just inboard of the brake. Air is supplied through a solenoid valve from an accumulator tank mounted near the brake cylinder. A time-delay device releases the brake load in about one-half second after it is applied to prevent a complete stall. A timer sets the brake every 1½ min, thus allowing adequate brake cooling time between applications. In 100 hr, 4000 stall cycles can be applied.

Calculations made from the strip charts during a test showed the time in which the engine speed was reduced from 2200 rpm to 500 rpm and the rate of deceleration. Fig. 4 shows the analysis of a typical record.

Endurance tests of diesel engines at the U. S. Naval Engineering Experiment Station are usually made in accordance with one of two schedules of cyclic operation or a combination of the two schedules. One cyclic schedule of 8 hr is made at constant engine speed and variable load to simulate generator service. The 24-hr schedule includes variable load and speed for propulsion service. Details of the schedules are given in Tables 1 and 2.

During the suitability test of a 4-cyl, 4-stroke, 25-hp, 1428-rpm, marine diesel engine suitable for powerboats there were indications of erratic operation and inconsistent and sometimes high fuel consumptions and exhaust gas temperatures. The fuel-injection pump and injectors, valve timing, and other adjustments were checked and found to be correct. The cylinder head was removed and excessive carbon deposits were found in the fuel spray passage leading into the combustion chamber. It appeared that the diameter of the passage was too small and that the fuel spray impinged on the wall of the combustion chamber.

Prior to starting a 1000-hr endurance test, the fuel spray passages were cleaned and then altered by increasing their diameter from ¼ in. to 5/16 in. and relieving the combustion-chamber wall at the passage with a ⅝-in. diameter milling cutter (see Fig. 5). During the first 216 hr of operation, the test was stopped six times to clean the carbon from the passages, an average of every 36 hr. The next alteration was to increase the inside diameter of the fuel-injector washer from 7/32 in. to 5/16 in. This change improved the performance; only two stops were made to clean carbon deposits during the next 224 hr. Finally, the fuel spray passages were enlarged to ⅜-in diameter and the test continued to 1064 hr. The specific fuel consumption values were exceptionally steady and engine operation was smooth. There were no heavy carbon deposits in the fuel spray passages or combustion chambers.

A record of the fuel consumption at rated load and speed during this test is presented in Fig. 6. The normal specific fuel consumption was 0.45 lb per bhp-hr. The test was stopped to clean carbon deposit each time it reached approximately 0.55 lb per bhp-hr.

## Dynamic Strain-Gage Tests

Small-scale dynamic strain-gage tests are also proving helpful in overcoming some of the failures being found when engine ratings are increased and weight per horsepower decreased.

The Baldwin SR-4 strain gage may be used. It is a constant-wire grid bonded to a paper or bakelite impregnated paper backing. The wire grid has a uniform change in electrical resistance for a uniform change in strain. These gages function satisfactorily up to 300 F and over a wide range of frequencies. To be of use in metal stress determinations, the gage must be bonded to the test structure so that the gage is strained precisely like the test structure at the point of gage application. This bonding is accomplished by the use of special cements.

The strain-gage technique was successfully used by Fairbanks-Morse, for example, to find out why cylinder liners were cracking on their light-weight 2-stroke opposed-piston engine.

Measuring and recording the changes in electrical resistance of gages under dynamic strain conditions was accomplished with a 12-channel bridge amplifier and a 12-channel recording oscillograph. The bridge amplifier fulfills three functions: first, as bridge power source; second, for bridge balance; and third, for bridge output amplification. The recording oscillograph contains galvanometers which, by means of small mirrors, reflect a light source onto a traveling photosensitive paper. A timed

pulse is recorded on this same paper. At the completion of each test, the gage balance should be checked to determine if the cement bond between the gage and the test structure has loosened, in which case the data would not be reliable.

Temperature compensation of each strain gage had to be determined and applied, since the gage temperature during operation increased above room temperature where the zero bridge balance was obtained. This was accomplished by two different methods. In some cases, dummy gages were applied to metal plates of like material loosely attached to the test structure as close to the active gage as possible. The actual temperature of each active and compensating gage was obtained by means of thermocouples and a null balance potentiometer. This small difference in operating temperature was recorded and used to correct the strain values measured by the recording oscillograph. In other cases, two strain gages were applied to the test structure at right angles to each other. This method is effective where space permits and where unilateral strain exists. The gage at 90 deg to the axis of strain will compensate for temperature changes in the test structure. In this case, the deflection of the gage under study must be multiplied by a factor of 1.3 to give the correct strain reading.

Each test was continued long enough to allow engine cooling water and lubricating oil to reach equilibrium temperatures. About 35 min of operation was required for each test run. Thermal equilibrium of the engine parts would have required much longer periods of stabilized load operation. The cylinder liner design consisted of two major parts. The outer water jacket sleeve fits over the liner proper, with water-tight seals at the top and bottom of the jacket. This jacket is considerably cooler than the liner. The tests indicated that the jacket operates 200–300 F cooler than the liner, due to the circulation of cooling water between them.

A 0.002-in. nominal diametral clearance at room temperature is very quickly taken up when the engine is started. The jacket then supports the liner. Firing pressures exerted on the inner surface of the liner are then supported by both members. Highest combustion pressures occur at the center of the liner where four threaded adapter holes are located. Several strain gages were applied to the outer surface of the liner jacket at the closest point to these adapter holes as was practical. Strain gages were also applied on the reduced thickness areas of the jacket. These cut-down areas were designed to reduce stress levels at the adapter holes, the points of greatest stress concentrations. Results of the tests conducted on this liner design showed considerable variation in stress level with differences in the clearance fit between the liner and jacket. It can be shown by calculation that as the stress in the jacket is reduced, the stress in the liner increases. Since failures have occurred in both members within a very few operating hours of each other, the total material supporting combustion pressures and thermal growth was not adequate.

A nodular iron stress belt was designed which pulled down around the liner jacket. Fig. 7 shows this assembly. The jacket was not reduced in thickness at any point in this design. Static strain-gage tests of this assembly showed a large reduction in stress level when the belt was installed. These results (plotted in Fig. 8) show that the stress belt reduced the stress level of the jacket near an adapter hole even when no interference fit between stress belt and liner jacket was used. When an interference fit was employed, greater stress reduction was

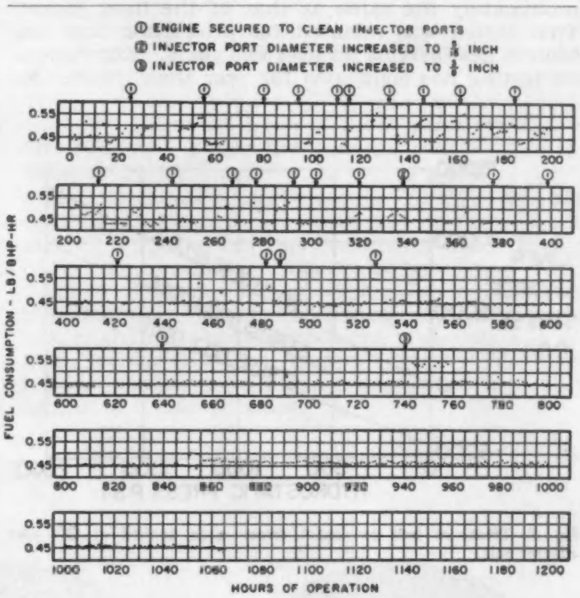
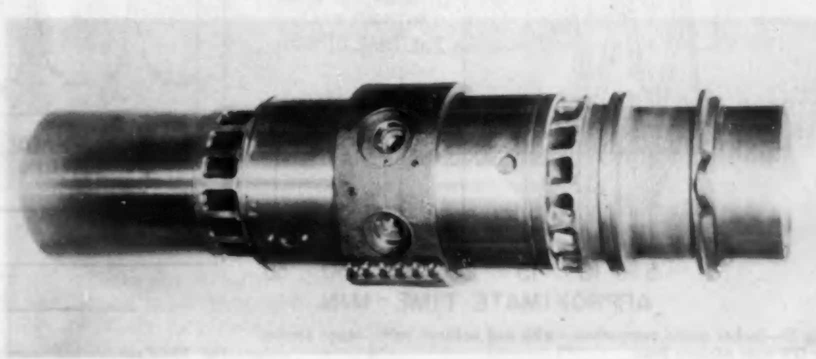



Fig. 6—Fuel consumption versus hours of engine operation.

Fig. 7—Cylinder liner with nodular iron stress belt pulled down around liner jacket.



accomplished. During operation, increased support of the liner and jacket is obtained due to the cooler operating temperatures of the belt as compared to that of the liner.

Dynamic strain-gage tests of the liner and belt assembly verified the static test trends. Fig. 9 is a plot of stress variation versus time. The large reduction in stress level of the outer surface of the water jacket is shown. The fluctuating stress level during the first 10 min of operation is due to changes in speed and load of the engine. All tests were conducted in this same manner. The relatively constant stress level for the last portion of the test run is at rated speed and load when cooling water and oil are reaching equilibrium temperatures.

Fig. 10 is a trace from a typical cylinder-liner jacket record. From spot points in these records, data for curves like Fig. 9 were obtained. Note the zero bridge balance line, thermal strain, maximum strain level, dynamic strain range, and the characteristic shape of the trace. The dynamic strain variations follow a pattern similar to cylinder pressure variation.

The stress level of the belt was found to be approximately the same as that of the liner jacket. This design was released for production and has been in fleet service for over two years. Experimental testing has continued for over three years. No reports of failures have been received during this period.

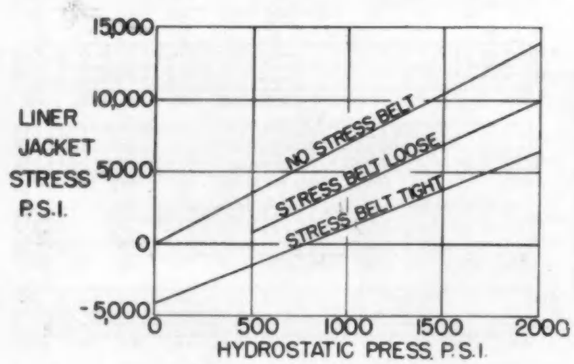



Fig. 8—Effect of belt on jacket stress—gage applied at OD near adapter hole.

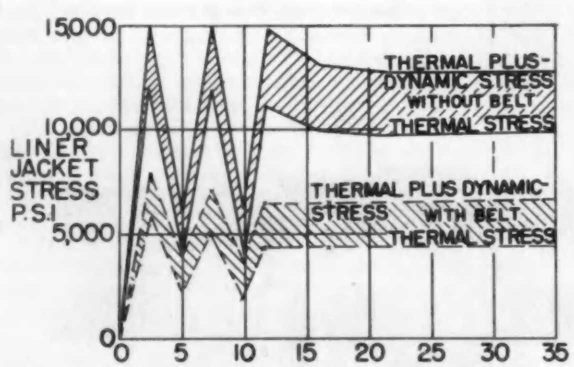



Fig. 9—Jacket stress comparison (with and without belt)—gage applied at OD near adapter hole.

## Aggravation Test

Another approach to the problem—attributed to the late Stanwood W. Sparrow, Studebaker's vice-president in charge of engineering for many years—that is proving helpful to some engineers in devising laboratory tests might be called the aggravation technique.

First, as in the normal approach, the problem must be analyzed and divided into its components, so that each factor contributing to the failure can be evaluated.

In the normal approach, each of the factors considered relevant to the deficiency is isolated and an attempt is made to eliminate them one at a time until the deficiency or product failure is overcome. The unfortunate attribute of this approach relates to the time required to conduct such a development, especially when many contributing factors are involved. For example, if a machine part is producing consistent failures in the test laboratory or in field service in 1000 hr of operation, it becomes necessary to conduct tests exceeding 1000 hr each time the effects of one of the variables surrounding the problem is modified. Obviously, a vast number of hours must elapse in such a procedure before the element responsible for the failure is isolated and correctively altered.

With the Sparrow philosophy, each of the relevant factors is again isolated, but then the approach begins to differ. One by one, these factors are aggravated rather than eliminated in a series of tests, so that if normal failures occur in a 1000 hr period, the identification of the significant factor or factors in the deficiency will become possible in a period of much less than 1000 hr. It is quite obvious that this will permit resolution of a critical product deficiency in a much shorter period of time than would be possible under the alternative operating procedure.

Such an approach will not always lend itself to the solution of an engineering problem. However, such procedures have been utilized in many cases with results which gave its users confidence that ignorance of such an approach is undesirable.

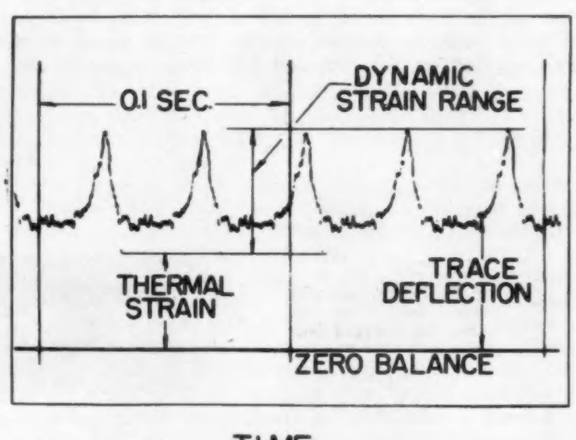



Fig. 10—Cylinder-liner record—gage at OD near adapter hole.

# How Abrasive Contaminants Affect Aircraft-Engine Performance

Based on paper by **F. E. Tobin, G. R. Furman, and K. H. Strauss,** Texas Co.

DETECTIVE work on what makes aircraft-engine parts wear shows that the culprits are often contaminants built into the engine during assembly, introduced during overhaul, or ingested during ground run-up.

Identification of these contaminants and their origin suggests certain solutions for these abrasive-caused problems:

1. Before assembly clean oil passages by a solvent flush which has a greater velocity than that of the oil used during service.

2. Clean lapped or honed parts by the brush and spray method.

3. Control size of grit used in blasting or honing.

4. Regularly inspect efficiency of parts cleaning methods.

Shown below are some of these abrasives and on the following pages the damage which they can cause to parts.

Here are some typical examples of these trouble-causing contaminants. From left to right (at 15 magnifications) they are quartz cylinder honing compound, alumina cylinder cleaner, and sand. They come from cleaning, repair, assembly, engine test stands, and line maintenance. But they are all harder than the common bearing materials and are often harder than the hardest engine steel. They will abrade or deform an engine part if rubbed against it under pressure.

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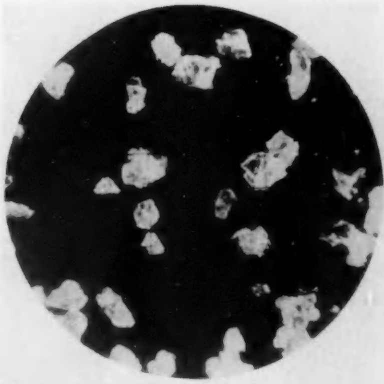
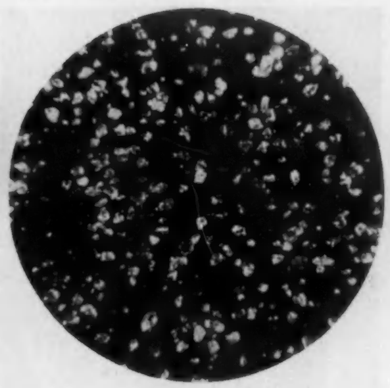
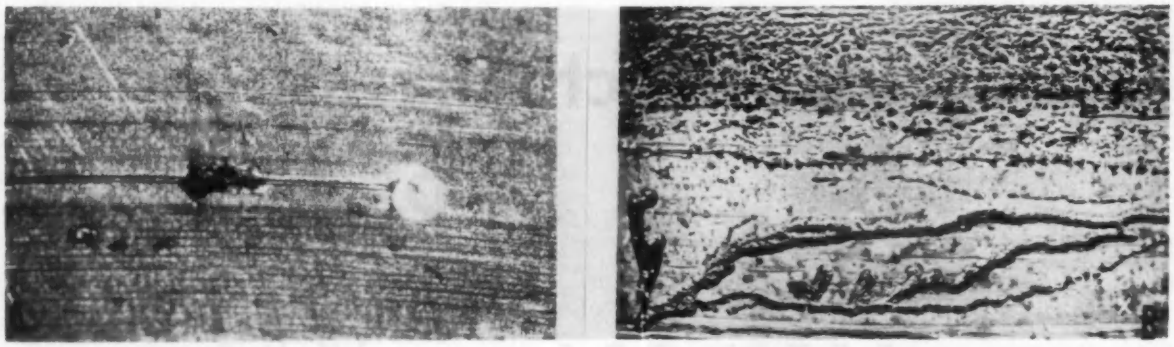
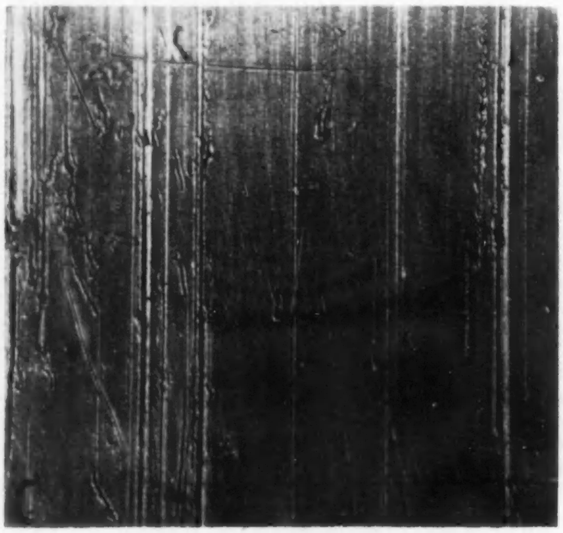




(Paper "Contaminants and Their Effects on Aircraft Engines" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

## Bearings

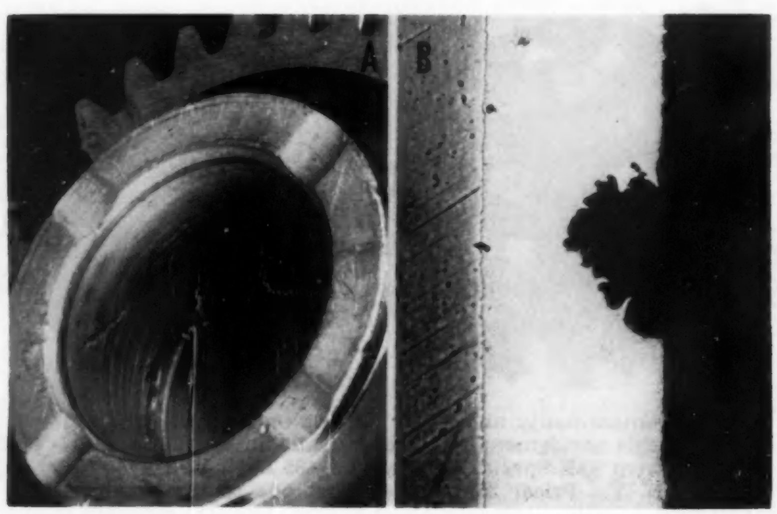




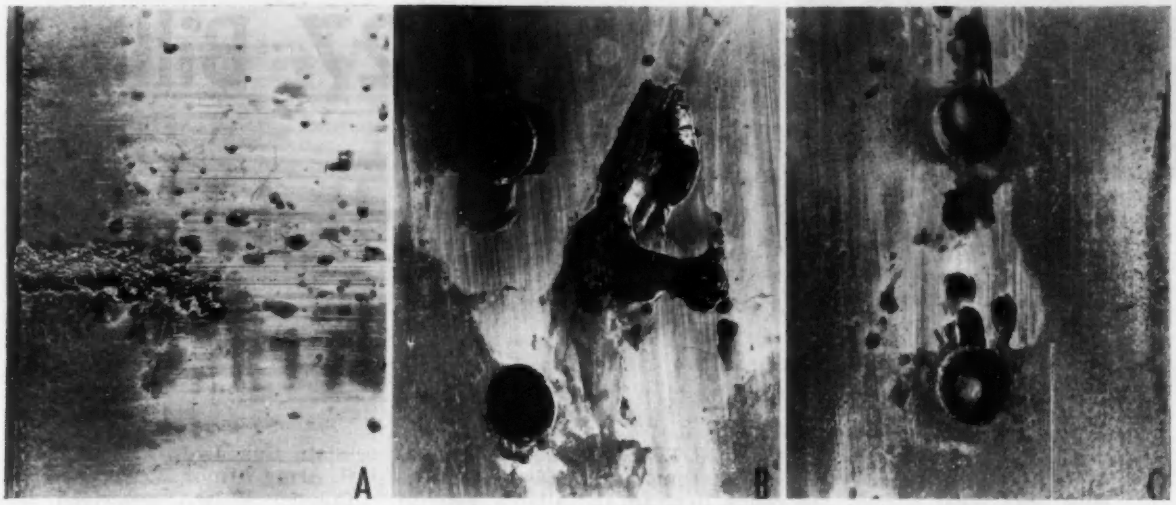
The low-power microphotographs above and at the left show what happens when small particles, such as steel chips, become trapped between a bearing surface and its mating shaft. They often are not completely submerged in the 0.001-in. lead coating on the bearing surface but stick out and cause scoring, as in A (slightly reduced from microphotographs taken at 30 magnifications). Slow migration of steel chips wedged between a reduction gear bushing and shaft caused the failure shown at B (also slightly reduced from 7 magnifications). At other times, the bearing surface may be scored, even though no embedment took place, as shown in C (reduced from 15 magnifications).

## Bearing Cavitation

Scoring or embedments may lead to more destructive cavitation erosion, as shown here. Such damage decreases bearing contact area and diverts the oil flow, leading to complete bearing failure. Cavitation damage in the gear bushing is shown as a diagonal line on the bearing surface in A (reduced from 3 magnifications). The microphotograph in B (reduced from 50 magnifications) gives a cross-section of this break showing the sharp contours of the groove edge and the depth of damage.



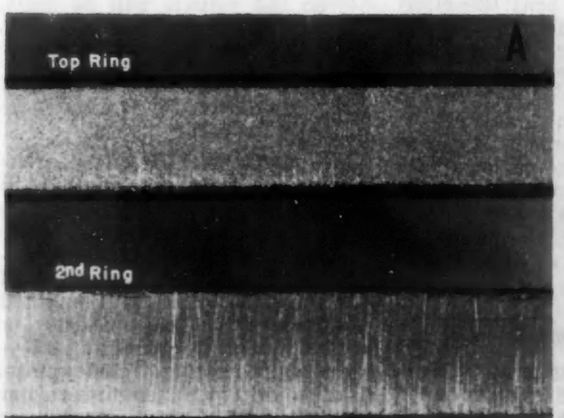
## Master Rod Bearing

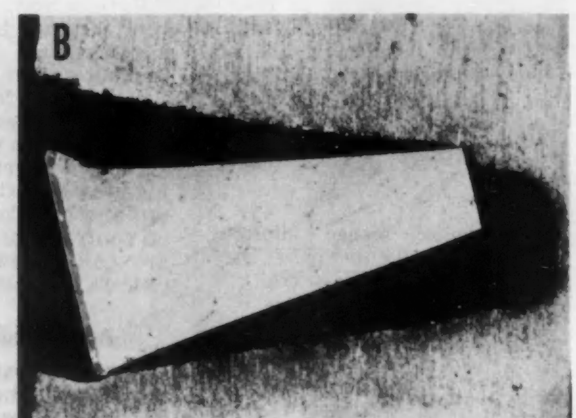



Several types of damage can occur here. Entrance turbulence of oil flow which contains contaminants may cause pitting as shown in A (reduced from 5 magnifications). An abrupt disturbance in the continuity of oil flow caused loss of metal. High-frequency vibrations, or cavitation, set up high surface forces which locally fatigue and pluck out the bearing alloy. B (slightly reduced from 5 magnifications) shows fatigue damage can also be produced. Here, a disturbing force pounded the bearing surface, stressing it repeatedly until it reached its endurance limit. The silver then cracked, and large pieces loosened and broke out, producing a 0.40-in. long cavity. Temporary embedment of solid particles can cause mechanical damage as seen in C (microphotograph slightly reduced from 5 magnifications). Particles squeezed beneath the journal at the point of maximum pressure depressed the bearing surface. The bearing metal, thus displaced, flowed out and up, creating a raised band around each impression.

## Pistons and Piston Rings

Abrasives in a cylinder can cause piston-ring face wear, as shown in A (slightly reduced from 8 magnifications). The harder top chrome face suffered less damage than the second cast-iron ring. This is invariably accompanied by ring side wear because rings scrape off some abrasives into ring grooves. Extensive ring side wear led to the ring and groove profiles as shown in B (reduced from 15 magnifications). The resulting increase in ring side clearance set the stage for ring flutter and land damage.



SAE Central Illinois Section's Eighth Annual Earthmoving Industry Conference was held this year in a movie theater directly across the street from the Pere Marquette Hotel. Its sessions have outgrown the seating capacity of the Hotel's largest ballrooms.

★ ★

**More than 1700** engineers attended the Eighth Annual Earthmoving Industry Conference at Peoria, March 26-27. That was a new record. Last year about 1400 came to this big SAE Central Illinois Section event.

★

**At the Dinner,** Section Chairman R. D. Henderson was toastmaster.

★

**Chairman of this year's Conference** was W. H. McGlade, LeTourneau-Westinghouse Co. Conference secretary was R. E. Seyfried; treasurer was E. E. Hansen. The committee chairmen upon whom McGlade relied for the successful event were: E. S. Cheaney, Finance; G. B. Grim, Program; K. L. Mason, Arrangements; J. A. Drais, Publicity; and M. C. Neul, Housing.

★

**Technical session interest** was high to the very end. The last session had 755 people . . . about 150% of the average attendance at the other three sessions.

# $27 Billion Highlights

KEYNOTING the Eighth Annual Earthmoving Industry Conference, Bertram D. Tallamy, Federal Highway Administrator, described the mule-drawn wagons with which he worked in his early days as a contractor, then quickly moved on to the gigantic program now under way which involves $27 billion to be spent in 13 years.

The job is 60 times as large as the Panama Canal undertaking, with 6 billion yards of dirt and rock to be moved; a 41,000 mile interstate system is to be built, directly linking 90% of our cities and 100 million people. In addition to the interstate system described above are the urban, primary, and secondary systems; work on these largely existing systems mainly involves breaking bottleneck, but here 755,000 miles of road are involved. All in all, the highway program is a construction job of unprecedented magnitude in the history of mankind.

Various ways to beat the engineer shortage in the highway administration were described. Computers can now be used to design bridges from certain given parameters—length, load, and so forth. A cross reference of design systems between the various state highway departments is being set up; another plan is to ask for bids on contracts before all the details are nailed down, a time saving process, if feasible.

### Army Needs New Vehicles

Ernst W. Spannhake of LeTourneau-Westinghouse Co. introduced the speaker for the first technical session, Col. J. J. Wilson of the U.S. Army Armor Board.

Colonel Wilson described the situation confronting the army today, and elaborated on the proposed solution in the so-called "GOER Concept" of vehicle design. It sounds as though the earthmoving industry very nearly has now what the army wants!

Since the army cannot run its transport fast, Colonel Wilson said, and since there are few paved roads in our current enemy's territory, it occurs that the army transport might as well get off the roads. And, if the vehicle leaves the roads, it might as well stay clear of the bridges. So, a need for a new vehicle configuration arises as follows:

1. Use four wheels only with large diameter tires.
2. Use positive power wagon steer.
3. Use exoskeletal (lobster-like rather than man-like) design so the vehicle will be light, yet rigid, and easy to float (as it must).
4. Make the vehicles airliftable, airdropable, or disassemblable for airlift.

Most off-road wheeled earthmovers, he said, are similar in basic layout to the suggestions above.

Questions brought out interesting points on the economics of the situation: One twin-engined earthmover costing $60,000 or $70,000 hauled the same as 14 2½-ton trucks costing $7000 apiece. And it did it with 2 engines rather than 14, with 4 tires (large, it is

# Highway Program Talk

# Earthmoving Conference

true) rather than 140 or so, with 1 soldier rather than 14, and, further, the earthmover should last several times as long as the trucks.

Questions regarding the ability to change tires shot out in battle were academic only, according to Colonel Wilson. After such a hit the driver would be off the vehicle and running in any case, and certainly not toward the flat tire to change it.

Colonel Wilson liked the diesel engines in most earthmovers because of their broader fuel appetites. In fact, he indicated that ability to burn crude would be highly desirable, thus eliminating refineries as strategic necessities and permitting the army to run on locally available fuels.

### Gears and Torque Converters

R. P. Van Zandt, Caterpillar Tractor Co., served as technical chairman for the afternoon session on March 26. He first introduced B. W. Kelley and R. Pedersen of Caterpillar Tractor Co., who jointly talked on "The Beam Strength of Modern Gear Tooth Design."

They reviewed presently used formulas and methods for determining the beam strength of gear teeth. A new approach, based on photoelastic work and combining features of two existing methods, was presented. Experimental results showing better correlation with the new method than with existing ones were presented.

J. B. Black and M. V. Dundore, Twin Disc Clutch Co., collaborated in a paper titled "Torque Converters Can Be Different." Dundore, presenting the paper, pointed out that quite a variety of characteristics are available by using different geometry within the converter, and that still wider characteristics are possible by coupling converter elements to planetary gearsets.

Answers to questions following the talk brought out that the converter can absorb up to 150% of the engine horsepower, which when added to the normal engine braking, results in appreciable amounts.

At the banquet, Edward McFaul, in a talk labelled "So You Think You're Slipping," put our normal abnormalities in the proper perspective through humorous discussion.

### Mobile Instrumentation

Wednesday morning's technical chairman was D. W. Erskine, Allis-Chalmers Mfg. Co.

W. D. Speight and W. H. Jones, Caterpillar Tractor Co., in their paper said the performance of earthmoving machines at work can be evaluated with the aid of a number of measuring instruments. This requires that instru-

**CHAIRMAN OF THE CONFERENCE W. H. McGLADE** congratulates keynote speaker Bertram D. Tallamy. Tallamy made a progress report of work under the Federal Highway Act of 1956.

**SECTION CHAIRMAN R. D. HENDERSON** (left) was toastmaster at the Conference Dinner. Edward McFaul (right) was the dinner speaker. His subject: "So You Think You're Slipping."

ments must go into the field with the machines being tested. It is the transportation and application of instruments under these conditions that we call mobile instrumentation.

Mobile measurements usually involve quantities varying rapidly with time. This is now commonly called dynamic measurement, and it results in the very extensive use of recording instruments as contrasted with indicating instruments for this type of work. In addition, the difficulty of analyzing data during a test run makes the possession of a permanent record for later study almost essential.

### Off-Road Locomotion

M. G. Bekker, of the Detroit Arsenal, told of commercial developments in off-the-road locomotion. They embrace a wide field, he said, in which earthmoving, logging, and agricultural operations are most common.

The problem of motion resistance encountered by a vehicle moving either itself or implements such as a scraper, plow, or a trailer, he said, has remained practically unsolved until quite lately. Recently, there has been proposed a new engineering approach to the whole question.

This new approach has led to the establishment of general semi-empirical principles which aid in the solution of the "plasticity problem," and appears to have led to a better understanding and more general evaluation of land locomotion.

Bekker then outlined equations for the determination of sinkage in terms of load and soil values, and an equation for the approximation of the relationship between soil strength parameters, ground pressure, and slippage.

He also gave applications of the discussed soil-value system by the solution of example problems.

Closing, Bekker said that his discussion was directed mainly at a demonstration that a solution of the problem of land locomotion is possible, but only within the methodological framework of applied mechanics, and that the lack of development in such a mechanics was due to the lack of an appropriate soil value system.

The closing technical session was presided over by W. J. O'Shaughnessy. It dealt with several recent design developments in the earthmoving field; the new International line of off-highway trucks and the Clark Equipment Co.'s power shift transmission. A glimpse into the future was offered with a paper upon the use of aluminum in earthmoving equipment.

### I. H.'s New Trucks

The first paper by K. J. Kolinger, "Development of the New International Payhaulers," presented International Harvester Co.'s design approach and development of their new line of off-highway trucks.

Six pilot models of each truck were fabricated in the experimental shop and then were placed on jobs in different parts of the country. This field test uncovered several deficiencies. Among the most important was the poor visibility afforded the driver. To improve this situation, the engine, transmission, and hood line were lowered so that the driver could see the ground some 40 ft—instead of the original 61.25 ft—ahead of the truck when looking over the radiator cap. It also was found that by tilting the top edge of the windshield forward, dust and dirt were prevented from settling on the glass. The outboard edge of the windshield was lowered so that the driver could see the ground directly in front of the left fender.

Maximum interchangeability between the trucks and the 4t-95 and 2t-95 wheel tractors was achieved, with all of the following parts interchangeable between the 4t-95 and the trucks:

1. Closed Cab—when used
2. Electrical System
3. Seat
4. Radiator
5. Rear Axle Banjo
6. Differential Head
7. Front Fenders Grille and Hood
8. Engine and Transmission
9. Engine Air Cleaner
10. Steering System
11. Engine Controls
12. Radius Rods
13. Front Wheel Spindle and Related Parts

### Tractor Shovel Developments

"Power Shift and Move More," the second paper at this closing session was by M. H. Conrad, director of engineering, Clark Equipment Co., Construction Machinery Division. He put forth

the concept that the wheel shovel had progressed through five stages of development from its original beginning as a "front end loader" on a farm tractor.

This includes its adaptation to a crawler tractor for flotation and traction; the addition of a bucket attachment for applications requiring speed and mobility; and the use of four-wheel drive with a full reversing transmission. The fifth and latest phase in the development of the tractor shovel has been incorporation of torque converters, power shift transmission, and complete drive lines specifically designed for tractor shovel application.

The need for this type of transmission stems directly from the usual application for this machine which requires fast cycling, with the machine traveling as much in reverse as in forward. Until recent times such a transmission was thought to be a design impossibility due to clutch heating problems and the severe stresses placed on the drive line. However, with the advent of the oil-cooled clutch and the torque converter, these two age-old problems were whipped, for it was proved that the torque converter would save the clutch and cushion the torque reversals in the drive line.

### Aluminum for Earthmovers

The concluding paper, "Aluminum in Earthmoving Equipment," was presented by W. C. Weltman, Aluminum Co. of America. It glimpsed the future aluminum may play in construction of earthmoving equipment. Weltman called attention to the accepted fact that the larger a piece of equipment is for a specific job, the more quickly and efficiently the job can be done. Unfortunately, the very weight of many present units make transportation of them a ponderous task. Hence, if increased capacity could be obtained with little change in gross weight, major progress would be scored.

Even if these factors were not important, the payload capacity of any vehicle, which is dependent upon the tires, wheels, brakes, and engine, could be increased from 10 to 15% by the use of aluminum, Weltman said.

Experience with both commercial and experimental applications is mounting rapidly; and aluminum alloy and welding techniques are presently available. Only further consideration by the design engineer remains before aluminum will become a valuable material offering increased efficiency and profit to both operator and builder alike.

**AT THE RECEPTION** just before the Conference Banquet, these military and civilian earthmoving industry representatives gathered: Standing, left to right: A. F. Campbell, Timken Roller Bearing Co.; Col. Roscoe Rector, USAF; Col. Anson D. Marston, USA; Com. Robert Stalter, USN; K. A. Waldron, Hyster Co.; E. J. Mercer, Allis-Chalmers Mfg. Co.; and G. J. Gaudaen, SAE staff representative. Seated, left to right: John A. C. Warner, SAE secretary and general manager; M. R. Yontz, LeTourneau-Westinghouse Co.; R. D. Henderson, chairman, SAE Central Illinois Section; Dinner Speaker Edward McFaul; W. H. McGlade, general chairman of the Conference; and G. E. Burks, Caterpillar Tractor Co.

# Experts Say:

# Small Nuclear Plants Unlikely

**DR. CLAYTON R. LEWIS,** Chairman, SAE Nuclear Energy Advisory Committee

THE small nuclear powerplant will have great difficulty competing economically with the small conventional powerplant, except in isolated applications. This is the clear implication of conversations with nuclear experts gathered at the recent Atomic Energy in Industry Conference. Trying to project nuclear potentials through the year 1980, most of these scientists feel the greatest promise for nuclear power is in the very large central power station.

This conference exhibited a markedly more cautious optimism about nuclear energy than was evident several years ago. AEC's W. K. Davis summed up the attitude when he said:

"We are at grips with the hard realities of developing and building real nuclear powerplants. This does not turn out to be an easy task. There are many difficulties and the way is not wholly clear."

Conventional fuel sources are more than adequate for the next 20-25 years. And, barring some unforeseen or unexpected major breakthrough, nuclear power costs will remain slightly higher than (or at best competitive with) conventional fuels.

There will be continued improvement in conventional power stations. However, the cost of power generation is not expected to decline, since technological advances are offset by increasing costs. The costs of nuclear powerplants under construction and design have increased considerably (sometimes double) over original estimates. It is no mean achievement to stabilize power production costs in an inflationary economy.

It is projected that two thirds of new industrial power station starts will be nuclear by 1980. This fraction has increased over estimates made two years ago.

Political and social aspects of nuclear power complicate the picture. Divergence of opinion over the "kilowatt race" is very evident. Some say that the way to proceed is actually to build plants even though they are not economical (and hence of necessity under government subsidy) and remain the world leader in nuclear power. Experience is all important.

Others hold that to build uneconomical plants under heavy government subsidy would be disastrous. If left alone, they say, United States industry could follow our present programs to more worth-while goals. The diversity of U. S. approaches cannot help but be the eventual victor in the economic development of nuclear power.

Points of general agreement among the experts are:

1. The government must call the signals.
2. Private industry cannot assume the entire economic burden of nuclear development.
3. The foreign market represents the most immediate market, but does not appear to be long range.
4. There is little prospect for competitive plants in the United States in the near future.
5. In the face of all difficulties, nuclear energy will eventually be established as a major energy source.

The proceedings of this conference will not be available for some time, so I am only able to report in detail on the sessions that I attended. Others of the sessions are of great interest and should be summarized from the word-for-word reports that are to be published.

Many other interesting ideas of interest to automotive engineers were brought out.

### Hot Laboratories

Significant features found in most of the 300 hot laboratories operating in the United States are:

(1) Provision of sufficient shielding between hot cells to permit the teardown of experiments, decontamination, and setup of new experiments in one cell, without restrictions imposed by the radiation field from adjacent hot cells.

(2) Wide adoption of ferro-phosphorus aggregate in concrete for shielding material. This concrete compares in density with ordinary concrete and barytes aggregate concrete as follows:

| | Approximate Density, lb/cu ft |
|---|---|
| Ordinary concrete | 145 |
| Barytes aggregate concrete | 220 |
| Ferro-phosphorus aggregate concrete | 300 |

In one instance it was stated that use of 30 in. of ferro-phosphorus aggregate concrete as the primary shield was sufficient to permit the safe handling of 100,000 curies of 1 Mev gamma radiation.

(3) Use of the ferro-phosphorus aggregate as a dry filler between steel plates to serve as portable radiation shields.

(4) Limitation of the width or depth of almost all of the hot cells described to a size of 6-8 ft. The reason for this limitation is the limited horizontal range of operation of the remote manipulation equipment currently available for use in these cells.

### More Than a Billion Dollars

More than a billion dollars has been spent or committed by United States industry and government to develop nuclear power systems.

One expert estimates that, by 1980, the average single unit generator will be in the 300-400 $MW_e$ range, with the largest machines of the order of 750 $MW_e$ output. Maximum steam conditions are projected as 1400 F and 7000 psi. There will be three stages of reheat with about 5% increase in efficiency due to utilization of an auxiliary gas turbine powered by combustion gases.

Another expert estimates that by 1963 the best nuclear plant will approximate the worst conventional plant in cost.

Many agreed that, for best economics, it is wise to steer clear of highly enriched uranium; that natural or slightly enriched uranium is the direction to be pushed with greatest vigor.

Making what he termed "blue sky" predictions, another expert opined that the future lies in molten-fueled reactors. He believes that:

Two-day-old fission products from molten reactors will be used to power aircraft. After the fission products are no longer useful for aircraft, they will be used to heat homes. Finally, they will be disposed of by pumping under high pressure into clay beds at great depth. Radiation from a reactor will be very useful, he said, when available at about 10¢ per kw-hr.

### Nuclear Energy Helps

Nuclear energy is helping to develop many new phases of industry.

New cladding techniques, welding methods, and new alloys are coming to the steel industry through the help of nuclear energy. Steels three times as hard as carbon steel have been developed.

Non-naval marine power, it was said, shows the greatest promise of early competitive nuclear power applications. (In this area, naval powerplants have limited application.) The tanker with 10-15% in-port time is more promising than the dry-cargo ship with a port time approaching 50%.

SAE CEP

COOPERATIVE ENGINEERING PROGRAM NEWS

## SAE Panel Seeks Measure of Servo Motor Impedance

IN an effort to find a dependable way to measure impedance of servo motors, SAE's Aircraft Precision Servo Motors Panel has asked the National Bureau of Standards to:

- Recommend which of three existing test methods they prefer.

- Establish servo motor characteristics when the preferred method is used.

Industry has encountered serious apparent variations in test results when Series Resonant Bridge, Parallel Tuning, or Wattmeter-Ammeter methods are applied to the same motors. Regardless of precautions taken to insure identical test conditions, results persistently vary.

Six motors have been contributed by industry for test purposes. Three are size 10, the others size 15.

The SAE group has requested that the following conditions be met:

1. Standard mounting plate shall be used—square plate, three times the major diameter, 3/16 in. thick, black anodized, heat insulating base. Unit to be mounted on small pilot diameter. (Plates will be furnished with units mounted.)

2. Ambient temperature to be 25 C ±5 C.

3. Pressure 30 in. Hg ± 2 in.

4. Unit shall be maintained at ambient temperature for minimum of 2 hr before starting tests.

5. Excite fixed winding at rated voltage for 1 hr. Measurements are to be made immediately following this period.

6. Measurements are to be made on fixed winding only.

The data to be determined are resistant, reactance, impedance and effective resistance. DC resistance is to be recorded at ambient temperature immediately after impedance measurements are taken.

In addition, information should be furnished on frequency, value of harmonics present in supply, accuracy of instruments and components used, and elapsed time between end of warm-up period and final measurement.

Measurements are to be made on three different days to determine repeatability of measurements.

## ISTC Creates New Testing Methods Division

A NEW Testing Methods Division of the Iron and Steel Technical Committee has been established, and is currently reviewing existing ferrous test methods which appear in the SAE Handbook.

The new Division's scope was set up by the ISTC's Panel Steering Committee. Designated Division 3—Testing Methods, it will function primarily as a supervisory group. It will be responsible for all ferrous test methods not already specifically assigned to an established ISTC division. Miscellaneous test methods not already a part of the work of existing divisions will be referred to appropriate ISTC groups.

Division 3 has the authority to recommend formation of new divisions or sub-divisions to handle the work of developing test methods. It will also take charge of test method projects of disbanded ISTC divisions.

ASTM test methods will be used wherever applicable to automotive usage.

At present 10 ISTC Divisions are engaged in developing test methods. They are Division 4—Residual Stresses; Division 5—Methods of Determining Hardenability; Division 9—Automotive Iron Castings; Division 10—Automotive Steel Castings; Division 20—Shot Peening and Blast Cleaning; Division 24—Low Temperature Properties of Ferrous Materials; Division 28—Tool and Die Steels; Division 29—Nuts, Bolts, and Fasteners; Division 33—Gear Metallurgy; Division 34—Carbide Cutting Tools.

### Participants

W. H. Mayo of the U.S. Steel Corp. is chairman of the Testing Methods Division. His associates are H. R. Boatman, Inland Steel Co.; P. H. Case, Chrysler Corp.; R. D. Chapman, Chrysler Corp.; J. G. Frantzreb, Caterpillar Tractor Co.; R. E. Harvie, Chrysler Corp.; A. N. Hoover, Oldsmobile Division, GMC; H. L. Fry, Bethlehem Steel Co.; G. Meldrum, Republic Steel Co.; C. H. Palmer, Diesel Equipment Division, GMC; J. J. B. Rutherford, Babcock-Wilcox Co.; E. H. Snyder, Austin-Western Works Division; J. E. Spittle, Ford Motor Co.

## AMA-ATA's New Measure of Truck Noise Loudness Endorsed by SAE

EQUIPMENT and procedures to be used in the scientific measurement of loudness of truck noise have been established by the Automobile Manufacturers Association and the American Trucking Association. At the request of AMA's Motor Truck Technical Committee, they will appear in the 1957 SAE Handbook as the Truck and Bus Noise Measurement Recommended Practice.

The method prescribed for the accurate measurement of truck noise loudness consists of recording the noise of the truck on a high-quality magnetic tape recorder as it passes by under load. The noise recorded is played back through a set of octave bandpass filters. Then, the maximum playback sound level reading of each band is converted to sones by established relationships, and the sones totaled for a single loudness reading for the truck.

The new report contains sections on necessary test equipment, test and laboratory procedures, calibration and instrument practice, and source of error.

## Technical Committee Profiles

Belitsos

**THE JOINT AERO-AUTO DRAWING STANDARDS COMMITTEE'S ALMOST EXCLUSIVE RECOGNITION OF THE USE OF THE COMPLETE SYSTEM OF DECIMAL DIMENSIONING** will have far reaching effects upon the next generation of engineers and designers, predicts **Chairman P. G. Belitsos.** Universities and grade schools alike will be affected by the switch from fractional dimensioning to the decimal system.

Increased use of the complete decimal system of dimensioning has raised the problem of limits interpretation. An interpretation establishing dimensional limits as absolute is being devised by the Committee.

A comprehensive standard on simplified drafting practices is being prepared. Entitled "Conventional Representation," it will be the first standard of its kind to record those sound simplified practices now widely used in industry.

By December 1958, the Committee expects to publish its new joint Aero-Auto Drafting Manual which will "combine the best features of the present separate Aeronautical and Automotive Drafting Manuals."

Roper

**PHOTOMETRIC REQUIREMENTS FOR 4-LAMP DUAL SEALED-BEAM UNITS** have been modified to provide individually for the beams from the Type 1 unit and the upper beam filament of the Type 2 unit, reports **Lighting Committee Chairman V. J. Roper.** Photometric requirements for the composite of these two beams have been eliminated. The change was made to provide for optical interchangeability. The modified Standard for Sealed-Beam Headlamp Units for Motor Vehicles was not approved in time to make the 1957 Handbook, but will be included in the 1957 Lighting Booklet, available approximately July 1.

Revisions of the Reflex Reflector Standard also have been completed and include modifications in details of test procedures. These changes will be included in both the 1957 Handbook and the 1957 Lighting Booklet.

A revision of the SAE Recommended Practice for Headlamp Testing Machines to cover headlight aiming devices is now underway. Effort is presently being directed toward securing agreement on a standard scale for aimers of this type.

Trowbridge

**STANDARDS FOR TUBULAR SPLIT AND SOLID RIVETS, HOSE CLAMPS, AND SNAP RINGS** will be revised and developed in subcommittees now being formed, reports **R. P. Trowbridge, chairman of the Parts and Fittings Committee.**

During the past year, members of the Parts and Fittings Committee structure completed projects on straight, grooved spring, clevis, dowel and cotter pins. Attention was also directed toward revision of tachometer and speedometer drive standards.

In developing standards for parts and components, Trowbridge recently pointed out that SAE's technical committees often uncover problems which do not lend themselves to immediate solution. One such situation is the attempt being made to standardize woodruff and square keys. The Parts and Fittings Committee, American Gear Manufacturers, and American Society of Tool Engineers are currently working on this problem.

## News Briefs of SAE-ASTM Automotive Rubber Group

THE following news briefs result from a March 12–13 Detroit Meeting of the SAE-ASTM Technical Committee on Automotive Rubber.

● **To evaluate the effects of the oil additives on rubber parts,** SAE's Fuels and Lubricants Technical Committee has requested that standard rubber formulations be established. A paper is being prepared on the subject by an SAE-ASTM task group, with the idea that it will eventually be presented at a meeting regularly sponsored by SAE's Fuels and Lubricants Technical Committee.

● **The amount of energy absorbed during impact testing and the service life of rubber parts under particular conditions** is being studied by the Impact Testing Sub-Section.

● **Preliminary information on flammability tests** is being accumulated for further study.

● **Flex test specs are being worked on by the Flexing Resistance Sub-Section.** The specs will be applicable to motor mountings, bushings, molded belts, dust seals, unreinforced diaphragms, brake boots, air springs, and other items including non-automotive products. The de Mattia machine will probably be specified for tension flexing, and the Goodrich Flexometer will probably be specified for compression-fatigue. Information on good flexing compounds is being gathered.

● **Power steering hose and assembly specifications** are being established.

● **Hydraulic brake hose specs** are being developed in cooperation with the Army Ordnance Department.

● **Work continues on the revisions of specs covering vulcanized compounds of natural, reclaimed or synthetic rubber, or rubber-like materials.** Tables are being modified which affect Durometer hardness, tensile properties, and various specific requirements such as heat aging, compression set, weather resistance, load deflection, oil immersion, low temperature resistance, tear, flexing, abrasion resistance, moisture absorption, flame and impact resistance, staining properties, and resilience.

● **A proposal has been made to change specs for airbrake and vacuum brake hoses.**

● **New nomenclature charts for oil seals** are being finalized for publication in the SAE Handbook. Leather seals

manufacturers also are interested in standardization of their items. Torque testing machines are being reviewed, and the problem of cold and high temperature set and its effect on seals, liners and oil rings was raised.

• **The seemingly irreconcilable differences between SAE standards for V-belt groove configurations and those of the Rubber Manufacturers Association are being** studied by E. O. Kimmich of Goodyear Tire & Rubber Co. Problems arise when an engine with SAE pulleys drives a commercial unit with RMA pulleys. An ISO committee of European manufacturers faced with a similar problem is studying the problem with the object of working out a single table of pulley dimensions.

## Turbo-Superchargers Studied By New Group

COST savings and interchangeability advantages for both turbo-supercharger and engine manufacturers will be realized through the proposed standardization work of SAE's new Turbo-Superchargers Subcommittee.

Created by the Engine Committee, the Subcommittee held its first meeting in Cleveland recently to outline items of major interest. Under consideration is standardization of connections for air inlet and outlet, exhaust inlet and discharge, methods of connections (flanges, clamps, "O" ring), oil and water connections, and nomenclature.

A questionnaire is being circulated to the Engine Committee to establish their preference with regard to existing and prospective connections.

J. A. Hardy of Schwitzer Corp. acted as temporary chairman at the Subcommittee's May 2 meeting.

## Fluid Connection and Seal Design for Aircraft Studied by New Committee

Chairman Scheffler

STATIC and dynamic fluid connection and seal design requirements for all applications in modern aircraft will be correlated by a new SAE Committee, Fluid Seal and Connection Design (AE-3). The new committee will collect and publish pertinent information on connections and seals for aircraft. It will function under the guidance of Chairman P. H. Scheffler of Westinghouse Electric Corp.

To reduce overlapping of activities or duplication of effort, fluid connection and seal design projects existing in or contemplated by SAE aeronautical working committees will be correlated by AE-3. Summaries of such projects will be circulated to the Aeronautics Committee, appropriate Aeronautics Divisions and working committees.

For the time being, projects will proceed in their respective committees. AE-3's coordination responsibilities include the privilege of recommending to the Aeronautics Committee and appropriate Divisions which, if any, existing projects might be combined, eliminated completely, or where further work might best be assigned for efficient handling. So states C. E. Mines, chairman of the Aeronautics Committee.

In the future, all documents related to fluid connection and seal design will be circulated to AE-3 members for comment simultaneously with their circulation to the handling committee.

Eventually, many seal and connection projects will be handled directly by AE-3. However, the new committee expects certain projects will best be handled by specialty committees.

Assisting Chairman Scheffler are William Whitesides, vice-chairman, Flight Refueling, Inc.; E. R. Bartholomew, Jr., Wright Air Development Center (WADC); D. D. Bruss, Beech Aircraft Corp.; F. W. Cowdrey, Parker Aircraft Co.; E. N. Cunningham, Precision Rubber Production Corp.; K. R. Durst, B. F. Goodrich Co.; D. J. Lipscomb, Lockheed Aircraft Corp.; Don Manning, Pratt & Whitney Aircraft; F. G. Mikel, Powerplant Division, Bureau of Aeronautics; Everett Roland, WADC; S. E. Sanfilippo, Navy Department, Bureau of Aeronautics; Henry Schmider, Bendix Aviation Corp.; R. F. Schwarzwalder, WADC; H. E. Wells, Bendix Aviation Corp.

Membership in AE-3 is expected to be increased in the near future.

## Technishorts . . .

**The Shielding Qualities of Conduits and Connectors Panel** recently conducted a survey which revealed inadequacies in existing cables and connectors. The need for new conduits and connectors stems from the fact that peak noise can now be measured. The first phase of the Panel's work is expected to be a survey of available documents. The Panel is part of SAE's Ignition Research Committee structure.

**An information report on low pressure, high temperature pneumatic ducting for aircraft** is being compiled by a Subcommittee of SAE's Aircraft Air Conditioning Committee. Experiences of various airframe companies and accessory manufacturers are being accumulated to determine which practices are acceptable for standardization.

**Form for Transmission Compression Springs, a proposed SAE Recommended Practice,** is in the last stages of development by the Design Standards Subcommittee. It has been circulated for comment to the SAE Spring Committee and is now being prepared for final action by the Transmission Committee.

**To encourage automobile manufacturers to leave space for radio units,** a proposal has been made to form a joint SAE-RETMA (Radio-Electronics-Television Manufacturers Association) task group. The proposed group would explore the possibility of getting radio manufacturers to agree on standardization of housing sizes. The proposal was made by the Physical Dimensions Subgroup of the Radio Communications for Automotive Fleet Applications Subcommittee.

**A Nomenclature Guide for Aircraft Engine Tools and Equipment** is being established in the form of a proposed Aeronautical Recommended Practice (No. 480). The proposal, which will not include aircraft engine parts, is being worked on by SAE's Aircraft Tooling Panel.

**Apparatus for accurate and economical determination of 20-hour discharge capacity and life cycling of storage batteries** is described in SAE's proposed Information Report, Equipment For Testing Storage Batteries. The Report is being prepared for inclusion in SAE's Electrical Equipment Booklet.

## SAE to Participate in New Kettering Award

SAE participation in the Charles Franklin Kettering Award has been approved by SAE Council—as have the rules drawn up to govern the Award. Charles M. Heinen and J. P. Charles have been named as Society representatives to the Award Board—Heinen for a one-year term; Charles for a three-year term.

The Award is "for recognition of those who have made creative accomplishments for the benefit of mankind including discovery, invention, improvements in design or processes within the relationships of materials and energy."

The Award is to be financed by individual contributions, which may be sent to American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y. Checks should be made payable to the Charles Franklin Kettering Award.

The first Award was made to Kettering himself on October 4, 1956.

The Award is sponsored by six engineering Societies, of which SAE is one. Other sponsoring Societies are: American Society of Mechanical Engineers, American Institute of Mining, Metallurgical and Petroleum Engineers, American Society of Civil Engineers, American Institute of Electrical Engineers, and American Institute of Chemical Engineers.

The SAE Past-Presidents Advisory Committee will function as the SAE body to find and transmit to the Board of Award suitable nominations for the Kettering Award.

## YOU'LL . . .

### . . . be interested to know that . . .

**T. F. NAGEY**, Glenn L. Martin Co., has been appointed a member of the SAE Nuclear Energy Advisory Committee.

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**SAE's Activity Committees have had eight new members appointed since January.** They are: **R. B. AULT** and **G. W. HALDEMAN** to the Air Transport Activity Committee; **E. A. ROCK** to the Aircraft Powerplant Activity Committee; **J. D. GRAHAM** and **P. P. MOZLEY** to the Engineering Materials Activity Committee; **H. J. A. CHAMBERS** to the Production Activity Committee; **J. P. HARMON** and **J. T. KULHAVEY** to the Tractor and Farm Machinery Activity Committee; and **H. O. FLYNN** to the Truck and Bus Activity Committee.

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**SAE's Meetings Committee and the three Aeronautic Activities**—Aircraft Activity Committee, Aircraft Powerplant Activity Committee, and Air Transport Activity Committee—will join with the American Society for Mechanical Engineers and the Institute of Aeronautical Sciences in cosponsoring a session at the ASME Semi-Annual Meeting in San Francisco, Calif., June 9–13, 1957, "Instrumentation—Human Engineering" and also four sessions at the ASME Annual Meeting, New York, Dec. 1–6, 1957, on "Jet Transports and Their Place in Air Cargo."

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**JOHN B. WASSALL** has been appointed as SAE representative on the Daniel Guggenheim Medal Board of Award for a term of three years beginning Oct. 1, 1957. He will be succeeding **E. C. WELLS** whose term will expire Sept. 30, 1957.

## Design of Final Drives For Industrial Vehicles

Based on paper by

**EDGAR S. CHEANEY**

Allis-Chalmers Mfg. Co.

DESIGNING a final drive for an industrial vehicle presents a difficult problem because of the considerable reduction that is generally encountered. This reduction causes heavy loads, which require large gears and bearings to carry them. The final drives must be mounted in housings sufficiently rigid to support the loaded member without undue deflection. Added to these heavy loads is the fact that the final drive, being directly connected to the driving sprocket, receives all the shock and vibration transmitted from the track links, rough terrain, and the drawn load. Thus, the final drive tends to become a bulky affair requiring considerable skill and ingenuity to fit it neatly onto the vehicle.

The design of a final drive for a tracked vehicle is generally commenced after a basic vehicle arrangement has been worked up, so that the approximate amount of dropdown is known, and the center of the sprocket or drive wheel is located. Also, from the gen-

## SAE National Meetings

### 1957

**August 12-16**
West Coast Meeting
Olympic Hotel, Seattle, Wash.

**September 9-12**
Tractor Meeting and
Production Forum
Hotel Schroeder, Milwaukee, Wis.

**September 30-October 5**
Aeronautic Meeting,
Aircraft Production Forum,
and Aircraft Engineering Display
Ambassador, Los Angeles, Calif.

**November 4-6**
Transportation Meeting
Hotel Statler, Cleveland, Ohio

**November 5-6**
Diesel Engine Meeting
Hotel Statler, Cleveland, Ohio

**November 6-8**
Fuels and Lubricants Meeting
Hotel Statler, Cleveland, Ohio

### 1958

**January 13-17**
Annual Meeting and Engineering
Display, The Sheraton-Cadillac
and Statler Hotels, Detroit, Mich.

**March 4-6**
Passenger Car, Body,
and Materials Meeting
Sheraton-Cadillac Hotel,
Detroit, Mich.

**March 31-April 2**
Production Meeting and Forum
The Drake, Chicago, Ill.

**April 8-11**
Aeronautic Meeting,
Aeronautic Production Forum,
and Aircraft Engineering Display
Hotel Commodore, New York, N. Y.

**June 8-13**
Summer Meeting
Chalfonte-Haddon Hall
Atlantic City, N.J.

eral proportions of the machine the pitch diameter of the sprocket will be established. Knowing this pitch diameter, we can relate the speed of the sprocket (rpm) to vehicle speed (mph). This sprocket speed is also the final drive output speed.

The type of final drive to be used will be determined by balancing considerations of cost against geometry. Since the least expensive type of final drive is the single reduction, it should be considered first. With the reduction, input speed, and power known, the size of the pinion for satisfactory life and tooth geometry can be found using regular gear design procedures. Knowing the pinion size and reduction, we can establish the center distance. With center distance known a trial layout can be made to see how the final drive can be fitted to the machine.

Once the basic arrangement to be used is decided on, the geometry of gear teeth, shape of shafts, and selection of bearings can be determined using standard design procedures. The design of the gear teeth is highly critical, due to the heavy loading generally encountered, and use is frequently made of long-short addendum teeth, crown shaving, and the like in order to stretch gear life to the maximum. Whichever type of bearings is used, the selections should be as conservative as space will permit. In designing the load-carrying components—particularly the shafts—great care should be exercised to avoid sharp fillets and notch effects, since final drives seem especially susceptible to fatigue failures in regions where stress raisers are present.

One of the most difficult questions encountered at this point in developing a final drive design is to decide on the configuration of the housing. This structure must be sufficiently rigid to maintain the alignment of the bearing bores so as to ensure correct gear tooth contact. At the same time the housing must provide some means for assembly, access, and service.

In regard to final drive housing rigidity, it should be pointed out that modern design techniques have been evolved that remove this problem from the influence of the designer's experience and instinct. In all such housing design where shapes are irregular and loading patterns complicated, the use of stresscoat lacquer and electric strain gages will show areas of stress concentration and magnitudes of deflection with reassuring consistency. These data will guide the designer in making a distribution of metal in the housing that will provide a structure of adequate strength at minimum cost.

(Paper, "Final Drive Design" presented before the SAE Central Illinois Section on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

# Briefs of SAE PAPERS

Presented below are brief digests of recently presented SAE papers. These papers are available in full in multilith form for one year after presentation. Order from SAE Special Publications, 485 Lexington Ave., New York 17, N.Y.. Price: 35¢ each to members, 60¢ each to nonmembers.

## AIRCRAFT

**Integration of F-100 Airplane Into Air Force Squadron Service, M. G. LONG.** Presented Jan., 1957, 5 p. Summary of experience and problems encountered in squadron as first tactical units in U S Air Force to be equipped with supersonic fighter; transition stages from North American F-86F aircraft with which squadron was equipped, to North American F-100A.

**Manufacturer's Philosophy of Meeting Today's Business Air Transport Requirements, D. L. WALLACE.** Presented Jan., 1957, 10 p. Acceptance of aircraft by businessmen as means of transportation; Cessna Aircraft Co.'s concept concerning various categories of single, twin and 4-engine aircraft; three examples representing three different size operations and types of users typifying American business needs; special reference to Model 620 4-engine pressurized private airliner.

**Development of Business Transport Aircraft, W. H. ARATA, Jr.** Presented Jan., 1957, 22 p. Major items airframe manufacturer must consider in development of new model, particularly in design of multiengine jet type business transport; importance of market analysis, analysis of customer requirements, and factors relating to aircraft availability; design problems relating to plane configuration, power plant selection, interior arrangements, etc; operational and economic aspects.

**Planning for Handling Jet Transport at Passenger Terminal, H. O. OLSON.** Presented Jan., 1957, 8 p. Modernization program, associated with approaching jet era discussed; sheltered entry for passengers and provision of fixed installations around aircraft at gate position such as fueling systems, d-c and a-c power supply from remote generators, underground manifold pre-conditioned air systems, pneumatic power for starting of jet engine, lavatory servicing, and baggage handling by conveyor systems.

**Hydrant Fueling, R. H. BARRETT.** Presented Jan., 1957, 14 p. Operating experience with large capacity hydrant fueling system, installed 2½ yr ago at San Francisco International Airport by Standard Oil Co. to handle fueling requirements including jet fuel from underground pipe lines; system which provides for hydrant connections at 19 terminal gate positions, is considered in three parts: satellite storage and pumps, pipe line system, and fueling carts.

**Transport Airplane from Pilot's Viewpoint, Capt. R. F. ADICKLES.** Presented Oct., 1956, 8 p. Pilot's viewpoint on cockpit instrumentation, water inerting, runway lengths, stepped climb, need for emergency measures, functional reliability.

## GROUND VEHICLES

**Why Does Your Car Wear Out, H. R. JACKSON.** Presented Jan., 1957, 6 p. Service road test program, undertaken by Atlantic Refining Co, shows that both oil-borne abrasion and low temperature corrosive wear account for total wear, other factors being minor; 12 medium price range 1953 V-8 cars of two different makes were each equipped with radioactive cast iron top compression ring; during test oil samples were taken and

Continued on page 146

# Aircraft Builders Face Biggest Challenge

Based on secretary's report by

J. E. MILES
Boeing Airplane Co.

NEW materials, designs, and fabrication techniques will be needed in the supersonic airplane of tomorrow. And tomorrow is virtually here.

The heat problem, created by high-speed flight, will have to be met by using materials, equipment, and parts which will operate without reliance upon artificial cooling. Many of these new materials will be required in production quantities before there has been experience in using them, hence there will be need for close cooperation between manufacturer and supplier, and need for multiple sources.

There are problems relating to titanium bolts, nuts, and screws, for example, which have yet to be solved to make these items satisfactory for the application intended. Large sizes of titanium sheet are needed and, at present, flatness tolerances are too great. Forgings of new, higher heat-treated materials are going to be needed; so are better quality steel castings.

Equipment for tomorrow's aircraft will need qualification testing and the scale will be such that it may be im-

practical for many small, but excellent suppliers to establish their own facilities. However, test equipment must be available and it should be under the control of the manufacturers.

(This article is based on the secretary's report of the panel on Future Procurement and Subcontracting Problems which was presented at the SAE National Aeronautic Production Forum. Panel leader was F. L. Dobbins, Boeing Aidplane Co.; panel co-leader was J. W. Hinchliffe, Jr., Northrop Aircraft, Inc.; secretary, J. E. Miles, Boeing Airplane Co. Panel members were: R. Nagely, North American Aviation, Inc.; R. W. Harker, Lockheed Aircraft Corp.; H. N. May, General Dynamics Corp.; W. G. Doran, Douglas Aircraft Co., Inc. This report together with other panel reports are available as SP-317 from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: $2.00 to members; $4.00 to nonmembers.)

# X-Rays Aid Aircraft Maintenance

Based on talk by

RALPH M. PARKER

Holger Andreason, Inc.

THE Androscope is a portable X-ray diffraction stress analyzer, which will measure either applied or residual stress in psi. It can also be used to detect fatigue in metal. By comparing these radiographs with some made of artificially aged samples, the number of load cycles any given part is able to sustain before danger of failure can be accurately predicted.

This is, of course, extremely important on highly stressed aircraft structural members such as wing spars, wing attach fittings, and empennage attach fittings. The equipment is simple to operate and almost foolproof on standard aircraft materials with a gain size of 4–10.

One example of its application occurred recently on jet-engine parts when either the instruments failed to indicate over-temperature in operation or at least the occurrence was not reported to the maintenance facility. During overhaul the engine parts were subjected to various inspections by every known medium of nondestructive testing. If no defects were found they were re-assembled and returned to service. Failures occurred at relatively short periods after overhaul, and metallurgical examination of the failed members indicated that the parts had been subjected to over-temperature of sufficient magnitude to cause a change in the grain boundary material that resulted in stress corrosion and ultimately failure.

With the Androscope and sample blocks of the material heated to various temperatures in 50-deg increments, a chart of the line width obtained on the diffraction films was prepared. With this chart to compare shots made on complete components, it was possible to tell at what temperature the engine had been operated to within 50 deg, and to replace affected parts during overhaul.

Any change in metal whether caused by manufacturing processes or by use is reflected in a change in the atomic lattice and therefore can be detected by such equipment as the Androscope.

The films, for example, of the lower front spar cap of a Delta DC-6 after 20,000 hr of operation indicated a very normal residual stress buildup. Shots were equally spaced along the spar from the fuselage to the outer wing panel. Only one film shows any indication of high residual stress and some fatigue. This point was closest to the fuselage, where, of course, the highest loads are encountered. By comparing this film with sample pieces of the same material that have been artificially fatigued in varying degree up to failure, the remaining service life can be accurately predicted and arrangements made to schedule replacement of the part long before any actual danger of failure exists.

Aircraft of higher speeds and more complex construction with fewer provisions for adequate inspection by the old methods make some such equipment as this mandatory. (Talk, "Use of X-Ray in Modern Aircraft Maintenance," was presented before SAE Atlanta Section.)

# Aircraft Design Influencing Production

Based on secretary's report

R. L. ANDREWS

Northrop Aircraft, Inc.

FUTURE aircraft technical requirements will include:

1. New materials and processes to meet higher temperatures.
2. Acoustic protection for higher sound levels.
3. Test facilities to meet new flight environments.
4. Better space utilization and improved maintenance for more complex equipment.
5. Better quality control and increased shop skills to provide improved reliability.

At the higher Mach numbers of future aircraft, higher temperatures will be generated on the surfaces of the aircraft. Aluminum skins will be replaced by titanium or steel skins, and new adhesives, elastomers, lubricants, and fuels will be used.

The noise generated by jet engines with afterburners will create sound levels in the order of 150 db in areas of close proximity to the jet wake blast. In such areas, new structural concepts must be used in order to wtihstand the high-frequency vibrations created by the propulsion system. In addition, certain internal systems must be designed to withstand the severity of high noise levels.

The new environments of higher temperatures, higher speeds, high noise levels, and increased thrust will require new testing facilities to perform such tests as:

1. Structural tests at elevated temperatures.
2. Aerodynamic tests in supersonic wind tunnels.
3. Propulsion tests, using jet rocket and nuclear powerplant systems.
4. Acoustic tests on both structure and systems.
5. Thermo tests on both the crew cabin and the complex servo systems that are subjected to the increased environment of high temperatures.

The increase in airplane performance also means new plant facilities such as:

1. High-temperature ovens, salt baths, and furnaces for the heat-treatment and processing of new heat-resistant materials. The total heat load of the plant will be greatly increased by these requirements.
2. More hard metal machining and forming equipment will be required for the fabrication of parts from steel and titanium.
3. The increased tolerances required by high-speed flight will require increased capability for close tolerance tooling and fabricating.
4. More manufacturing research facilities will be required for the development of new production processes.

These new facility requirements imply the need for more preflight testing, and for more preproduction (experimental) component manufacturing to decrease the time span between design and combat-ready aircraft.

The increase in complex airborne electronic apparatus presents problems in achieving desired reliability, while at the same time requiring more space within the airframe. This runs contrary to the trend toward greater density of future aircraft to achieve high performance levels. Better use of the space within the aircraft is needed, but achieving at the same time improved maintainability.

(This article is based on the secretary's report of the panel on Future Technical Requirements held at the SAE National Aeronautic Production Forum. Panel leader was R. B. Jackman, Northrop Aircraft, Inc.; panel coleader was G. W. Papen, Lockheed Aircraft Corp.; secretary, R. L. Andrews, Northrop Aircraft, Inc.. Panel members were: C. W. Bentley, Douglas Aircraft Co., Inc., D. E. Graves, Boeing Airplane Co.; R. L. Kurtz, North American Aviation, Inc.)

# SECTIONS

JUNE 1957

## Increased Attendance Tops List of Section Achievements

A recap of the year's activities shows that it has been a fruitful one for Sections and Groups. Most Sections have reported a pickup in Section attendance and a greater percentage of total Section members are turning out for Section meetings. This indicates that the percentage of members on hand for meetings has increased in relation to attendance by guests. An important reason for this has been selection of more interesting meeting topics and better recognized speakers. Also credited with increased meeting attendance are promotion by company representatives, use of telephone squads, and an improvement in meeting notices.

#### Council Action

To assure greater strength in new Sections and Groups, the Executive Committee recommended, and the Council acted, to require a minimum of 50 members in a local area, with a potential of 100, before the Council will consider a request for recognition of a new SAE Group. Further, at least 60 per cent of the members must hold Junior and/or Member grade of membership. The number of members required before a petition for Section status may be considered has been increased to 100, with a minimum of 60 per cent of Junior and/or Member grade of membership. This step-up in the number of members and the ratio of technical members gives greater stability to new local SAE organizations, a continuing source of officer material, and a sound basis for future growth.

#### Members at Large

At the recommendation of the Sections Committee Executive Committee, the Council amended the Society's By-Laws to increase the number of members-at-large of the committee from three to five, and the period of appointment from three years to five years. This change will help to provide an important increase in the continuity of the Executive Committee.

The committee also recommended additional Activity and Regional vice-chairmen to the Council for the Atlanta, Baltimore, Central Illinois, Alberta, and Mid-Continent Sections.

A subcommittee of the Executive Committee has been considering revision of SAE Section Procedure, working toward developing this publication as a more definitive and more helpful handbook for Section officers and committeemen.

## Section Meetings

BALTIMORE

**June 22** . . . First Annual Summer Dance

CANADIAN

**June 21** . . . Oshawa Meeting. Guest Speaker **George B. Morris,** Jr. Top Official of Labour Relations Section of GMC

CLEVELAND

**June 13** . . . Annual Golf Outing. Elyria Country Club. Elyria, Ohio.

DAYTON

**June 13** . . . June Jamboree. Springfield Country Club, Springfield, Ohio. Dinner 6:30 p.m. Special Features: Golf, Kickball, Swimming.

MILWAUKEE

**June 22** . . . Ladies Night. Ozaukee Country Club.

## BALTIMORE

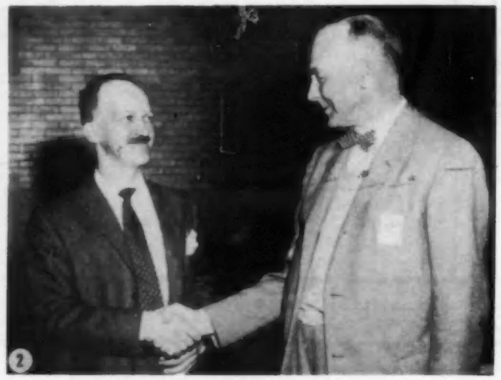
*D. E. Woomert, Field Editor*

Baltimore Section Governing Board members have adopted the popular telephone committee idea combined with a letter and return reservation card which replaces the post card meeting notice.

Prompting the change was the fact that many of the members of the Baltimore Section live in outlying communities and the post card notices often did not reach these people until the day of the meeting. The first class letters reach everyone in ample time even though they are not put into the mail any sooner. The letter makes it possible to give more complete details and also to publicize coming events.

With the reservation representative on the telephone committee, it is possible to make reservations up until the last day.

# From Section Cameras



**1.** Guest speaker at the April meeting of the **Baltimore Section** was **G. H. Maxwell**, national director of maintenance, Hertz Stations Division, Hertz Corp., who discussed "What is New in Vehicle Maintenance."

**2.** **S. H. Knight** (right), **Twin City Section** chairman, welcomes featured speaker **Robert Connor**, administrative assistant, product study department, Ford Motor Co., to the Section's Family Night meeting held April 10.

Topic discussed was "Safety Considerations in Automobile Design."

**3.** Shown in the foreground enjoying the Family Night spirit are Section Secretary **Albert Preston, Mrs. Preston,** and their three sons.

**4.** **Virginia Section** members are shown on the Section's field trip to the motor maintenance shops of the Transportation School at Fort Eustis.

The group spent the day at the Army post inspecting facilities at the home of the Army Transportation Training Command.

**5.** **R. E. Walker** (right), Program chairman for **Mid-Michigan Section's** April 8 meeting, greets **John Burnell,** Chevrolet Motor Division, General Motors Corp., who described the development of fuel injectors in his talk "Chevrolet's Fuel Injection."

**6.** **Mid-Michigan Section Chairman Earl Wilson, Jr.** (right) chats with **Harry S. Golden,** recently retired staff engineer of the Buick Motor Division, General Motors Corp.

# From Section Cameras

**1.** Shown addressing the **Western Michigan Section's** April 2 meeting is **Edgar L. Mosshamer,** Socony Mobile Oil Co. of Detroit. Three films entitled: "Pay Day at the Brick Yard," "The Fastest Mile Ever Driven," and "The Other Side of the Mountain," were presented.

**2.** **Kansas City Section Chairman Charles A. Slater, Jr.** (center) joins the April 23 meeting speakers **Paul O'Shea** (left), consulting engineer for Daimler Benz, and 1955–1956 United States Sports Car racing champion, and **Peter de Paolo** (right), head of Ford Motor Co.'s Endurance test program and 1925 winner of the Indianapolis Speedway Classic.

**3.** Gathering after the technical session at **Philadelphia Section's** April meeting for some impromptu entertainment are (left to right) **Andrew W. Wright,** Sun Oil Co.; **Emil Gohn,** assistant manager, Atlantic Refining Co. and SAE vice-president representing Transportation and Maintenance in 1945; **Cecil M. Billings;** and **O. M. Thornton,** district manager, Titeflex, Inc.

**4.** **SAE President W. Paul Eddy** (left), guest speaker at **Philadelphia Section's** April meeting, presents a certificate in recognition of 35 years' membership to G. Ralph Strohl, staff engineer, Autocar Division, White Motor Co.

Also awarded certificates honoring 35 years' membership in the Society were **Adolf Gelpke,** director of manufacturing, Autocar Division, White Motor Co. and SAE past vice-president representing Truck, Bus and Railcar Engineering in 1936; and **Matthew J. Farrell,** industrial engineer, Industrial Mobilization, Department of the Army.

**5.** **Philadelphia Section Chairman Andrew T. Browne** (right) is shown with 25-year members (left to right) **John P. Tarbox,** construction engineer and patent expert; **Russell Prickett,** professor of engineering; and **Melvin Comer,** district sales manager, Johnson Lawn Mower Corp.

# KANSAS CITY

*C. Abrams, Field Editor*

Youths of Kansas City are under strong consideration thanks to the SAE Kansas City Section.

In conjunction with many other technical organizations in the area, a group was formed in 1954, and named the Professional Engineers Vocational Guidance Council.

The purpose of the group is to give guidance to young people who have leanings toward engineering and technical careers.

The Professional Engineers Vocational Guidance Council is made up of representatives of 19 local sections of technical Societies, including SAE. The work of the council consists primarily of furnishing speakers to local high schools and colleges, providing information on college courses, preparing brochures on various aspects of engineering endeavors, and suggesting how to prepare for a successful career in engineering.

Besides working directly with the schools, the P.E.V.G.C. participates in various civic functions. The Council makes the arrangements for the engineering portion of the city-wide Kansas City "Career Day."

Also inaugurated was "Engineers' Day" during which hundreds of students from the Kansas City area gather. After a general address, separate groups are formed in accordance with the students' interest and different fields of engineering are discussed on an informal basis.

**J. D. Redding (right), chairman of SAE Kansas City Section Student Committee, was chosen to award a slide rule to Ted Smith whose subsonic wind tunnel was judged the best demonstration of the application of automotive engineering principals as applied land, sea, or air vehicles in the Kansas City Science Fair. At left is G. B. Kearns, Indian Hills Junior High School science teacher who sponsored Ted.**

## From Section Cameras




**1.** **Charles Leister** (left), technical chairman for the April 24 meeting of **Northern California Section**, introduces **W. E. Morris**, supervisor, antiknock group, E. I. duPont de Nemours & Co., Inc., who discussed "Abnormal Combustion in Automobile Engines."

**2.** At the same meeting, **Ernest S. Starkman**, College of Engineering, University of California, described ionization gap studies made on a CFR engine at the university.

**3.** **Holly P. Bradley**, safety supervisor, Service Pipe Line Co., is shown with some of the props he used in his lecture on highway safety at the **Mid-Continent Section's** March 29 meeting.

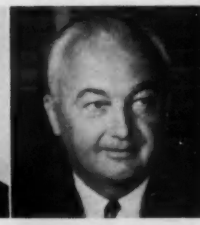
**4.** **Texas Gulf Coast Section's** March 8 meeting was a symposium spotlighting automotive air conditioning.

Panel members from left to right are: **Charles T. Moore**, American Motors Corp.; **A. L. Voggenthaler**, ARA Mfg. Co.; **D. L. Davis, Jr.**, Studebaker-Packard Corp.; **Melbourne Martin**, the Post, moderator; **John Moren**, Chrysler Corp.; **Robert R. Mandy**, General Motors Corp.; and **Fred D. Taylor**, General Motors Corp.

# About SAE Members


Lou


Williamson


Hurley


Gates


Warner


Kimbell


Baldwin


Burgess

**NILS H. LOU** has joined Reynolds Metals Co. as manager of manufacturing for the company's Parts Division in Louisville, Ky. His responsibility will cover all Parts Division manufacturing facilities.

Previously Lou was with Republic Aviation Corp., joining them in 1952, and serving as chief manufacturing engineer and subsequently as works manager. Before joining Republic, Lou was vice-president and tractor plant manager at Harry Ferguson, Inc.

**ARTHUR J. WILLIAMSON** has been named president of the Tube Reducing Corp., Wallington, N. J. Formerly executive vice-president, Williamson joined Tube Reducing as a vice-president in 1951.

Prior to his work at Tube Reducing, he was with Summerill Tubing Co. as chief metallurgist and plant manager in Bridgeport, Pa., and also manager of the Summerill plant in Carnegie, Pa.

**ROY T. HURLEY** has been elected a director of the Manufacturers Trust Co. He now serves as chairman of the Curtiss-Wright Corp.

**RICHARD L. GATES** has been made chief engineer of the Sterling Engine Co., Menominee, Mich.

Gates was formerly senior project engineer for Thompson Products, Cleveland, Ohio, and senior design engineer with Auto-Lite, Toledo, Ohio. He has also served as chief engineer of Curtis Auto Devices, Dayton, Ohio, and is now a member of the board of directors of that firm.

**DR. EDWARD P. WARNER,** SAE president in 1930, and retiring president of the Council of the International Civil Aviation Organization, has been made the first honorary member of the International Society of Aviation Writers.

The honor was given to Warner "in recognition of a lifetime of inspiring leadership and devoted effort in the cause of internationalism, civil aviation, aeronautical education, and professional aviation writing."

Warner is a veteran aviation writer, having served as editor of *Aviation Magazine* from 1929 to 1934. Prior to that he was associate professor of aeronautical engineering at M. I. T.

In 1926 he was named to the newly created post of Assistant Secretary of the Navy and later he was named vice-chairman of the Federal Air Commission. In 1938 he became a member of the Civil Aeronautics Board. He has been ICAO Council president since it was formed in 1945.

**ARTHUR W. KIMBELL** has been elected chairman of the board of directors of United-Carr Fastener Corp., Boston, Mass.

Kimbell graduated from the University of Illinois in 1913, was appointed general manager and elected to the board of directors of the United-Carr Corp. in 1929. He has served as president and general manager of the corporation since 1942.

Prior to 1929, Kimbell was president of Cinch Mfg. Corp., Chicago, Ill., a subsidiary of United-Carr.

**WALTER D. BALDWIN** has been made assistant general manager of the Tire Division of United States Rubber Co. Formerly he was executive assistant to the vice-president and general manager of the company.

Baldwin has been with US Rubber since 1935. He worked as a tire salesman before being named manager of the Salt Lake City district and later the Portland district. In 1944 he was in charge of sales for the Gillette Tire Division and subsequently sales manager for the U.S. Tires Division. In 1947 he was made director of manufacturers sales and later executive assistant. His new headquarters will be in the New York office.

**C. M. BURGESS** has been appointed by the governor of Illinois to a three man Commission responsible for the building and, ultimately, operation of the Illinois State Toll Highway System.

Burgess, formerly president and treasurer of the Burgess-Norton Mfg. Co., Geneva, Ill., has been named chairman of the board of the company.

**PERRY WALTER PRATT,** formerly chief engineer, Pratt & Whitney Aircraft Division, United Aircraft Corp., has been named assistant engineering manager for the company.

Pratt received a B.S. in mechanical engineering from Oregon State College in 1936. He then joined Pratt & Whitney as a test engineer. He was later made assistant project engineer, project engineer, and subsequently head of the technical and research section of the gas turbine department. In 1950 he was named assistant chief engineer and chief engineer in 1952.

Pratt served as SAE vice-chairman of the Southern New England Section in 1945.

**ARTHUR WILLIAM EDMOND** has been made regional manager—central region, New Departure Division, General Motors Corp.

He has been with GMC since 1935 and, prior to the new position, was zone manager—Indianapolis zone for the New Departure Division.

**MARION R. JOY** has been named research engineer, Engine Division, Caterpillar Tractor Co., Peoria, Ill. Formerly he was senior engineer, engine development, John Deere Waterloo Tractor Works, Waterloo, Iowa. In his new post he works with engine development and testing in the research department.

MacPherson

Kucher

Raviolo

Tallberg

Haynes

Frey

**EARLE S. MacPHERSON**, formerly vice-president—engineering, Ford Motor Co., has been appointed vice-president and adviser—engineering policy, at the staff level.

**ANDREW A. KUCHER** has been elected a vice-president of Ford and appointed vice-president—engineering and research. He was recently appointed director of the Engineering Staff. Prior to that appointment, Kucher served as director of Ford's scientific laboratory.

**V. G. RAVIOLO** and **V. Y. TALLBERG** have been named special assistants to Kucher. Previously, Raviolo was director of the advanced product study and engineering research office. Tallberg had been serving as executive assistant to the vice-president in charge of engineering.

**ALEX L. HAYNES**, formerly executive engineer, product study, Ford Engineering Staff, has been named director of the advanced product study office.

Haynes is the chairman of SAE Motor-Vehicle Seat Belt Committee.

**DR. DONALD N. FREY** has been named director of the engineering research office, Engineering Staff, at Ford. Since 1955, he has been an associate director of Ford's scientific laboratory.

**GEORGE W. WOLF**, president of the United States Steel Export Co., United States Steel Corp., has retired.

Wolf served ten years in Argentina and Europe with the Overseas Operations, General Motors Corp. In 1926 he returned to this country as vice-president of GM Overseas Operations in charge of production and engineering with headquarters in Detroit. Two years later he was transferred to N. Y. as operations manager. He resigned from GM in 1938 to become president of the Export Co.

In 1948, at the request of the Secretary of the Army, Wolf headed two missions to Germany, sponsored by a Joint Committee of Congress and the ECA. The first was to conduct a survey of steelmaking facilities with a view to increasing production. The second mission to Germany was to continue the study of steel production problems in relation to plants scheduled for removal as reparations.

In 1949, at the request of the Pakistan Government, Wolf organized a mission to that country for the purpose of surveying steel requirements based on Pakistan's program of economic development.

Wolf is a director of the National Foreign Trade Council and a member of the Council's Policy and Executive Committees. In 1955 he received from the National Foreign Trade Council the Captain Robert Dollar Memorial Award. He is also a member of the Council on Foreign Relations.

**ROBERT H. EATON**, mechanical engineer, has joined the Guided Missile Research Division, The Ramo-Wooldridge Corp., Los Angeles.

Eaton's experience includes research and development at the University of Michigan as project engineer in charge of dynamometer laboratory and supervisor of automotive laboratory. He also has been an assistant professor of mechanical engineering at the University at Ann Arbor, Mich.

**WALTER F. ROCKWELL** and **FRED W. PARKER, JR.** were elected to the board of directors of the Rockwell Spring and Axle Co., Coraopolis, Pa.

Rockwell, a Detroit industrialist, is chairman of the finance committee, Rockwell Mfg. Co., and is a director of the Robertshaw-Fulton Controls Co.

Parker is a vice-president of Rockwell Spring & Axle Co. and general manager of the Axle Division.

**FRANK J. HAHN** has been named chief inspector for Florida Operations, Pratt and Whitney Aircraft Division, United Aircraft Corp. He has served in the aircraft industry for 16 years, working for Pratt & Whitney Aircraft from 1940 to 1945, and in the Fairchild Engine Division from 1946 to 1956.

In March of 1957 he returned to Pratt & Whitney from chief experimental engineer at Avco-Lycoming Division, Avco Mfg. Co.

**JOHN. A. C. WARNER**, SAE secretary and general manager, has appointed **JOSEPH GILBERT** as assistant general manager of the Society. Gilbert most recently has been manager of the SAE Technical Committee Division of the Headquarters staff.

Gilbert

He previously was assistant manager of the Publication Division.

Stoner

Staiger

**M. L. STONER**, previously manager of the Technical Committee Division's aeronautical department, succeeds Gilbert as manager of the Technical Committee Division.

**DAVID L. STAIGER** becomes assistant manager of the Publication Division. He has been a staff engineer in the Technical Committee Division.

Marble

Meldrum

Two new staff engineers in the Technical Committee Division are: **WILLIAM I. MARBLE**, who has been manager of service engineering and service parts, Aircooled Motors, Inc. and **JOHN A. MELDRUM, JR.** who previously was a staff industrial engineer at the Navy Bureau of Ordnance.

**RANDALL ROMAN** and **WILLIAM E. IRWIN** are two SAE members named to administer the Engine Division of Caterpillar Tractor Co., Peoria, Ill. as department heads. The division will move to new facilities north of Peoria during 1958 and 1959. Roman will serve as chief engineer. Irwin will serve as service manager.

**FENTON LLOYD BAGLEY, JR.** is now with the Ordnance Corps, United States Army, Aberdeen Proving Ground, Aberdeen, Md. He is attending the basic ordnance officers training course.

Formerly Bagley was engineer, hydraulic control development group, Bendix Products Division Missiles, Bendix Aviation Corp. He is now on a leave of absence from Bendix.

**CHARLES WARREN WOOD** has been made chief engineer, Automobile Division, Clifford Mfg. Co., Boston, Mass. In this position he is responsible for all engineering of automotive thermostatic devices. Previously, Wood was senior project engineer, Standard-Thomson Corp., Vandalia, Ohio.

Prior to joining Standard-Thomson, Wood was associated with General Electric Co., Schenectady, N. Y. He holds over 60 US and foreign patents.

**JOSEPH R. SEGUIN** has joined Ford Motor Co., Dearborn, Mich., as product development engineer. Previously he was with Rockwell Spring & Axle Co., as field sales manager in the Timken-Detroit Brake Division.

**LT. GEN. LAURENCE C. CRAIGIE,** former commander of the Allied Air Force in southern Europe, has joined American Machine and Foundry Co. as assistant to the defense products group executive.

**WALTER F. SIMON** is now design engineer, Transport Division, Boeing Airplane Co., Renton, Wash. Formerly Simon was project engineer, Engineering Staff, Ford Motor Co., serving in Dearborn, Mich. and Cleveland, Ohio.

**FRED ERNEST WEICK** has joined Piper Aircraft Development Center, Vero Beach Airport, Fla., as director. In his post he directs the design, construction, and development of new model aircraft for the parent company, the Piper Aircraft Corp., Lock Haven, Pa.

The first project will be preparation for production of the Ag-3 experimental agricultural airplane, which was designed and constructed largely of Piper parts by the Texas A & M Aircraft Research Center. Previously Weick was director of the aircraft research center, Texas A & M College System, College Station, Texas.

In 1937, Weick served as SAE vice-president representing Aircraft Engineering.

# SAE MEMBERS IN THE NEWS


THE NEW YORK TIMES

WILSON AIDE GETS POWER TO SPEED MISSILE PROGRAM

Projects Put Under Holaday to Push Intercontinental and Medium Weapons

WASHINGTON, May 13—Charles E. Wilson, Secretary of Defense, disclosed steps today to stimulate the development of intercontinental ballistic missiles and those of 1,500-mile, or intermediate, range.

The United States efforts to develop an intercontinental mis-

W. M. Holaday

THE New York Times in its May 14 edition had the following to say about appointment of **W. M. HOLADAY,** SAE Technical Board member and SAE Past Vice-President for Fuels and Lubricants Activity as "the new czar of the big-missile program" . . . the appointment having been made by Secretary of Defense **CHARLES E. WILSON,** a member of SAE since 1914:

"Charles E. Wilson, Secretary of Defense, disclosed steps today to stimulate development of intercontinental ballistic missiles and those of the 1500-mile or intermediate range.

"Mr. Wilson also announced an administrative reorganization to hold down the costs of the Vanguard earth satellite program.

"He granted broadened authority to William Marion Holaday, his newly appointed special assistant for missiles development. When a new job description for Mr. Holaday became available, it revealed that the Vanguard project had been placed under his direct authority.

"Holaday, for many years director of research for Socony Mobile Oil Co., joined the Government early in 1956 as a Deputy Assistant Secretary of Defense. Early in May, Wilson made him his Special Assistant for Guided Missiles.

" 'He is a soft-spoken man and gets along well with people of all stations', says one scientist who has worked closely with Holaday. 'But he is not a man to be pushed around.'

"The new missiles chief will need ability to dig in his cleats and hold his ground in the approaching critical phase of the big-missile program."

**EUGENE L. MENCH** has joined the engineering department of the Diamond T Motor Car Co. He will serve as staff engineer on special assignments.

Mench has an automotive engineering background of more than a quarter century, starting with the now defunct Service Motor Car Co. Prior to joining Diamond T, his positions included that of special product engineer of American Motors Corp., and transportation engineer with the Motor Truck Division of International Harvester Co. He also spent five years with the Ordnance Division in Detroit, in the motor truck section.

Mench has been a member of SAE since 1919. He has served on the National SAE Truck and Bus Activity Committee from 1953 to 1955.

**FRANCESCO G. BONMARTINI** has joined the staff of Esso Research & Engineering Co. Formerly he was with the Imperial Oil Ltd., Sarnia, Ont., Canada, as a research chemist in the research department.

Bonmartini was graduated from the Institute Leonardo da Vinci in Rome, Italy, and from Rome University. He has been assigned to the company's Products Research Division.


Sanders


Rosenberger


Roensch


Farley


Brundrett


Plexico


Flynn


Mair


Hitch

# *Changes at Chevrolet*

**RUSSELL F. SANDERS** has been named director of sales and engineering, Rochester Products Division, General Motors Corp., Rochester, N. Y. Formerly he was assistant chief engineer, Chevrolet Motors Division, General Motors Corp. Sanders was chairman-elect of the SAE Detroit Section.

**M. S. ROSENBERGER** has been named assistant chief engineer of Chevrolet Motor Division, General Motors Corp. He is now in charge of engine and passenger car chassis design.

Rosenberger is a 30-year veteran of GM, with early association in automatic transmission development both at Cadillac and GM Staff. He joined Chevrolet in 1952 and was named assistant chief engineer in charge of experimental test operations in 1956.

**MAX M. ROENSCH** has been made assistant chief engineer in charge of experimental test operations. Before joining the Chevrolet staff in 1954, he had been with several concerns acquiring engineering and research experience. He has headed the GMC experimental laboratories since 1954.

**NELSON E. FARLEY, JR.** has been named director of experimental laboratories. He has worked with several concerns in automotive or related fields from 1939 to 1954 when he joined Chevrolet. He was named director of Chevrolet's proving ground operations in 1955.

**GEORGE A. BRUNDRETT** has been made director of Chevrolet Proving Ground activities. In 1944 he worked with the Delco Products Division of GMC and came to Chevrolet in 1952 as a research and development engineer. Three years later he was placed in charge of passenger car development work for Chevrolet at the GM Proving Ground.

**R. S. PLEXICO** has been named to the newly created post of chief truck design engineer of the Chevrolet Motor Division, General Motors Corp. In addition to co-ordinating truck chassis and body engineering, Plexico will work with the sales department at a policy level in truck design matters.

Plexico joined Chevrolet in 1934 and was made assistant chief engineer in 1954.

**H. O. FLYNN**, formerly staff engineer for truck chassis design, Chevrolet, has been named assistant chief engineer in charge of truck chassis.

**A. C. MAIR** has been made staff engineer for frames, suspensions, steering, wheels and tires, tools and related parts for Chevrolet. Previously he was assistant staff engineer for truck chassis.

**P. E. HITCH**, formerly Chevrolet assistant staff engineer for special commercial and military vehicles, has been named staff engineer for axles, brakes, transmissions, clutches, drive lines, radiators and fans.

**DAVID K. HART** has joined the Philco Corp., Philadelphia, Pa., as section engineer, Government and Industrial Division. Previously he was director of market analysis, Sharples Corp., Philadelphia. Hart supervises a group of engineers and technicians engaged in design and development of mechanisms for fire control, radar equipment and related products.

**HARRY M. DENYES** and **ARTHUR R. HEMPE, JR.** have joined O & S Bearing and Mfg. Co., Whitmore Lake, Mich. as sales engineers.

Denyes was, previously, Detroit sales representative, Ross Gear and Tool Co., Lafayette, Ind. Hempe formerly was manager of the Chicago office of Houdaille Industries, Inc.

**DONALD M. THOMPSON**, an aeronautical engineer with the U. S. Army Chief of Transportation, has been named vice-president for the southeastern region of the American Helicopter Society. The Society is a professional organization whose membership includes aircraft manufacturers, operators of aircraft, and representatives from Government departments.

**MERRILL J. ANDERSON** has been made automotive engineer in the eastern region of Ethyl Corp.'s sales department. His headquarters will be in N. Y.

Anderson has been associated with the Detroit research and development laboratories of Ethyl for the last 18 years. He has been active in many research projects in the diesel and gasoline engine fields. In recent years, he has been a member of the agricultural engineering section of the laboratory's Technical Service Division.

**T. N. LEO PUGHE** has been made manager of the Motor Fuel Division, Natural Gas Company of Florida. Previously, he was manager of the Industrial Engine Division, Reo Motors, Inc.

Prior to joining Reo Motors, he had been with the British Air Ministry at Rolls Royce; Ford Motor Co. in Great Britain; and Packard Motor Car Co. in Detroit, during World War II.

**RUSSELL J. KELLER** has been made engineering assistant to the vice-president of the American Machine and Foundry Co. of New York City. Prior to this post he was director of engineering for the Cleveland Welding Division of the same company. In his position he coordinates engineering of the general product group.

**HAYRI ADANALI** is now in Turkey where he is serving in the army. He received a B.S. degree in Mechanical Engineering from Robert College in Istanbul and a M.S. degree from Purdue University. In 1955 he started working for Twin Disc Clutch Co., Rockford, Ill. as a design engineer and subsequently was named to application engineering.

**F. I. GOODRICH** has been named staff manager to the vice-president, administration, of Eaton Mfg. Co. He has been general manager of the Spring Division of the past 6 years.

**EDWARD H. LINDEMAN** has been made general manager of Spring Division, Eaton Mfg. Co., Detroit, Mich. Previously Lindeman was assistant general manager. He joined the Perfection Spring Co. shortly after graduation from the Case Institute of Technology.

When Eaton acquired Perfection Spring in the early 1930's, Lindeman became associated with the Bumper Division and later the Stamping Division of Eaton. He rejoined the Spring Division in 1933.

**MORRIS C. ANDERSON** will be, for the next two years, serving with the U. S. Government in Bolivia, South America. He will be working as an instructor and technician there. Previously Anderson was head of the department of diesel technology, Oregon Technical Institute, Oretech, Ore.

**HAROLD W. GRUBE** has been made development engineer at Johnson Motors, Waukegan, Ill. Previously he was junior engineer for the company.

**HOWARD CLARK ISLAND** is now an aviation officer candidate, United States Navy Reserve, Pensacola, Fla. Formerly he was quality analyst, New Departure Division, General Motors Corp.

Island has served as chairman of the SAE Student Branch, General Motors Institute.

**WALTER J. OLIVER** has joined Automatic Transportation Co., Chicago, as layout engineer. Previously he was with Electro-Motive Division of General Motors Corp., La Grange, Ill.

**WILLIAM MICHAEL HUGH STEVENS** has been named technical manager of Bowser International, Ltd., London, England. Previously he was assistant to the technical director of All Wheel Drive Ltd. His new organization is associated with Bowser International Inc. of New York.

**DONALD G. STONG** has been transferred from the Southeastern region, Cummins Engine Co., to the home office in Columbus, Ind. Previously he was a representative in the region and now has been named a field application engineer.

**F. R. MEEHAN** has joined the New York Central Transport Co. of New York City as director of fleet maintenance. The company is a trucking subsidiary of the New York Central Railroad.

Formerly Meehan was vice-president of maintenance and purchasing, Buckingham Transportation, Inc., Rapid City, S. Dak.

# *SAE Fathers and Sons*

**CHARLES W. FREDERICK (right), director of engineering at the Detroit Diesel Engine Division of General Motors Corp., is shown with his son, LT. CHARLES WALTER FREDERICK, JR.**

**Lt. Frederick is a project engineer assigned to missile vehicle work at the Detroit Arsenal, Ordnance & Tank Automotive Command.**

**Frederick, Sr., has been a member of SAE since 1924 and his son has recently been elected to membership in the Society.**

**SAE Journal roving photographer catches an SAE Father and Son team looking over the program at the SAE National Aeronautical Meeting held in New York in April.**

**SAE father Frank C. Mock (right) is director, fuel systems engineering, Bendix Products Division, Bendix Aviation Corp. His son, Russell R., is administrative assistant to the director of economic planning, Curtiss-Wright Corp.**

**The elder Mock, an SAE member since 1911, was SAE vice-president for Aircraft Powerplant Activity in 1952.**

Polk

Cary

Skowbo

Goodwillie

Reiners

Kendall

Huda

Deardorff

Sanders

McGinn

Chandler

Laderer

**LOUIS F. POLK,** president of the Sheffield Corp., Dayton, Ohio, delivered the first of a series of annual Eli Whitney Memorial Lectures sponsored by American Society of Tool Engineers.

Polk is a vice-president and group executive of Bendix Aviation Corp., of which Sheffield is a subsidiary. He was chosen to deliver the inaugural Eli Whitney Lecture "in recognition of the demonstrated superiority in the quality of his achievements and caliber of his professional service to the tool engineering profession, to industry and to the American standard of living."

Following the delivery of the first lecture, Polk was presented with the ASTE's Eli Whitney Memorial Plaque.

**BEECHER BANCROFT CARY** has been made vice-president—engineering, Standard Products Co., Cleveland.

He joined Standard Products in 1951 as director of engineering and research. Prior to this he was vice-president of engineering and director of engineering and research at Hughes Industries, Jackson, Mich.

**JOHN J. GOODWILLIE** has been named a vice-president of Dole Valve Co., Chicago, Ill. He has been with Dole since 1939, serving as assistant vice-president in charge of sales.

**ELMER A. SKOWBO,** manager of the Detroit office of Dole, has been made an assistant vice-president of the company. He has been serving with Dole since 1929.

**NEVILLE M. REINERS** has been named vice-president—research, Cummins Engine Co., Inc., Columbus, Ind.

He has served with Cummins for 20 years in capacities of design engineer, technical analyst, manager of research laboratory, manager of research and refinement and director of research.

**JULIUS KENDALL** has been named vice-president in charge of sales of Arkwin Industries, Inc., Westbury, N. Y.

Formerly, Kendall served with Greer Hydraulics Inc., N. Y., for 11 years as general sales and service manager; vice-president, sales; and vice-president in charge of the Research and Development Division.

**EDWARD V. HUDA** has been named to direct research and development for the adhesives department of Raybestos-Manhatten, Inc., Bridgeport, Conn.

Huda has been with the research and development department of the firm's Raybestos Division since 1946.

**C. E. DEARDORFF** has been named manager of the new sales office in Calif. of Minnesota Rubber and Gasket Co. Previously Deardorff was chief hydraulic engineer for Bendix Aviation Corp.'s Pacific Division.

He will be responsible for sales activities of all Minnesota Rubber divisions, covering the California area.

**RUFUS CEDRIC SANDERS** has been named resident engineer, Chrysler Corp., Newark, Del. Formerly he was assistant chief engineer, Plymouth Division, for the company.

In his new post he represents Chrysler Central Engineering and other division engineering groups in the solution of all problems which arise with the automobiles produced in the Delaware plant. He also acts as a consultant on quality of the product with all departments in the plant.

In 1928 Sanders joined the engineering department of Chrysler Corp. Since that time, he has been engineer in charge of rubber and related parts, project engineer at Plymouth on airplane parts machining, engineering quality manager of the Plymouth Division and, until recently assistant chief engineer of Plymouth, covering operations in the Evansville assembly and body plants.

**HOWARD J. McGINN** has retired as chairman of the board of Eaton Mfg. Co., Cleveland, Ohio. His retirement terminated 45 years of active association with the automotive parts industry.

McGinn joined Reliance Mfg. Co. of Massillon, Ohio, in 1913 as manager of its Chicago office and was made general sales manager of the Reliance home office early in 1920. Subsequently he was elected vice-president and general manager.

In 1931 Reliance was acquired by Eaton and McGinn was elected a director and was named vice-president in charge of all sales. During World War II he also acted as general manager of the Reliance Division.

In 1951 he was elected president and member of the executive committee of Eaton, and chairman of the board as well as president in 1956.

**MILTON EVANS CHANDLER,** cofounder of Chandler-Evans, now a division of Pratt & Whitney Co., Inc., has retired from active duty with Chandler-Evans.

After receiving a B.S. degree from the University of Wisconsin, he entered Stromberg Motor Devices, Chicago, Ill. He remained with the company as a vice-president until 1935 when he left to form his own organization, Chandler-Groves, Detroit, Mich.

This later became Chandler-Evans and subsequently a division of Pratt & Whitney Co., Inc. Chandler has been a member of SAE since 1917.

**LEWIS C. LADERER,** previously sales manager of Wells Specialty Co., Inc., has been named vice-president and director of sales for Wells.

He served with the Aluminum Co. of America before joining Wells and entering into the aluminum extrusions.

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## About SAE Members

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**MICHAEL SCHINAGEL** has been named project engineer, General Electric Co., M. & O. S. department, Philadelphia, Pa. Prior to this post he was project engineer, Aviation Gas Turbine Division, Westinghouse Electric Co., Kansas City, Mo.

**MILTON F. ENGLISH** has been made parts sales manager, Federal Motor Truck Division, Napco Industries Inc., Minneapolis, Minn. English previously lived in Honolulu, where he served as president of Consolidated Equipment Co., Ltd.

**ROBERT M. CROMWELL** has been named development engineer at Manning, Maxwell & Moore, Inc., Danbury, Conn. Previously he was with Ford Motor Co. as resident engineer, gas turbine controls.

Hubert

Henning

**CLARENCE A. HUBERT,** formerly manager of engineering of the Farm Tractor Division, International Harvester Co., has been appointed general manager of the Construction Equipment Division.

He joined the Harvester organization in 1937 as an engine designer at Tractor Works and has subsequently served as chief engineer of the Farm Tractor Division, assistant manager of engineering, and, since 1946, manager of engineering for the division.

**W. W. HENNING** will succeed Hubert as manager of engineering for the Farm Tractor Division. Since 1955 he has been serving as assistant manager of engineering for the division.

He has been with the company since 1935 when he started as a draftsman at McCormick Works.

**W. R. DALENBERG** has been appointed assistant manager of engineering, Farm Tractor Division, to succeed Henning. Previously, he was divisional chief engineer in charge of the product engineering group, farm tractor engineering department.

**RAYMOND C. HAEFNER** has been made an assistant chief engineer, Battery Engineering Division, Electric Auto-Lite Co., Toledo, Ohio.

He has been with Auto-Lite since 1935. Formerly he was chief chemist and plant engineer at the company's Niagara Falls Battery Plant. In his new post he will direct the commercial engineering and customer engineer contact functions of the division.

Haefner is now serving as a member of the SAE Storage Battery Subcommittee of the Electrical Equipment Committee.

**ARSHAM D. ZAKARIAN** has been named chief project engineer, turbine production, Solar Aircraft Co., San Diego, Calif. He has been with Solar since 1940, and directly connected with the form's gas turbine work as project engineer since 1946.

Zakarian is an active member of SAE and author of an SAE paper on the Solar 50 hp Mars gas turbine engine.

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## About SAE Members

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**ALFRED REEVES** has retired as advisory vice-president of the Automobile Manufacturers Association. He has served with the AMA for 43 years.

When the National Automobile Chamber of Commerce was organized in 1914, Reeves was named the first general manager. In 1943 the organization changed to its present form as the AMA. When the headquarters were changed from New York to Detroit, Reeves continued as advisory vice-president and manager of the New York office.

Reeves has had a part in all 42 of the National Auto Shows, including the 1956 show. At that time he was honored as "Mr. Auto Show."

During World War I he represented the automotive industry in Washington and traveled the country in the drive to recruit skilled mechanics for the new Air Corps. In 1934, he was the Automobile Code Authority for the National Recovery Administration. During World War II he served on the Rubber Priorities Committee and the Automotive Council for War Production.

Reeves has been a member of SAE since 1913.

**HARRIS EDWARD DARK** has become owner of Ozarks International, Springfield, Mo. Previously he was export manager, Sun Electric Corp., Chicago, Ill.

His company handles all export sales activities of Reynolds Mfg. Co., Springfield, Mo.; Laclede Metal Products Co., Lebanon, Mo.; Ebert-Allen Battery Co., Joplin, Mo.; and Wheat Electric Co., Springfield, Mo.

In addition to his company activities, Dark is the author of over a dozen magazine articles and several text books and technical manuals of Automotive interest.

**H. WILLIAM OETJEN** is now western region sales manager for Pendleton Tool Industries, Los Angeles. Formerly he was national sales manager and director of research and development for the company. He is now in charge of eleven western states.

**G. LAWTON JOHNSON** has been named president of the Greer Marine Corp., Freeport, L. I., N. Y. Formerly Johnson was vice-president of Greer Hydraulics, Inc., parent company of Greer Marine Corp.

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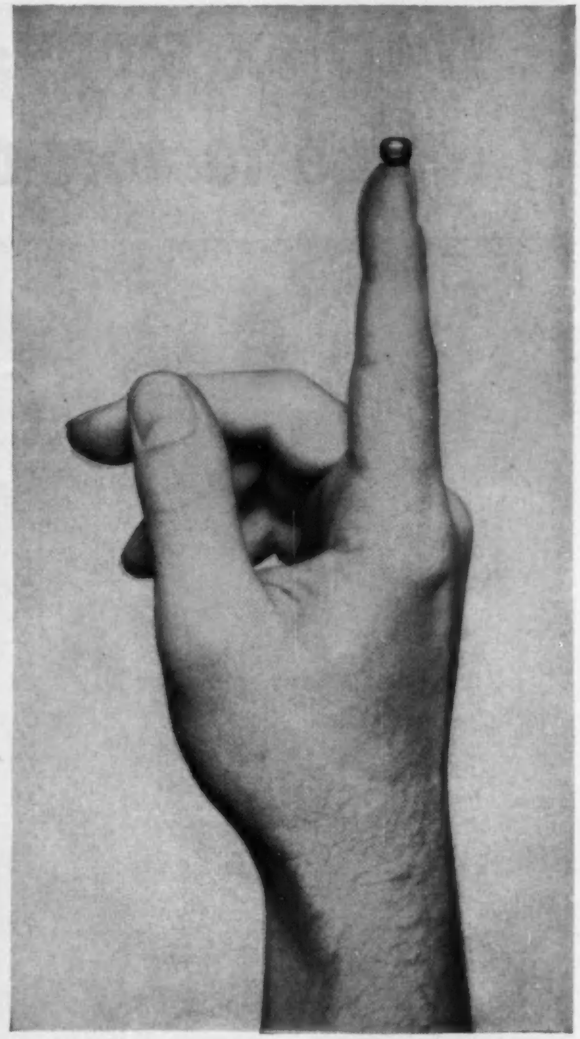

# Does *weight* limit use of metal powder?

One of these metal powder parts is light, the other heavy. And while each varies widely in appearance and characteristics, *both* were easily produced by Moraine Products from metal powder.

Unit costs are less because each part could be mass-produced in a single press operation. Yet, the closer-than-ever tolerances that resulted in improved on-the-job performance were maintained.

Moraine Products has the experience gained from the production of hundreds of millions of metal powder parts in an infinite variety of shapes and sizes. Countless application problems have been solved through our experience in powder metallurgy. And, because we recognize the limitations as well as the advantages of metal powder, each specific assignment is studied and judged individually.

When we accept a job to make metal powder parts, it is only after thorough study has shown that the customer will receive parts of the highest uniform quality for dependable end-product performance. Of course, on-time delivery is assured, regardless of quantity.

Moraine Products also produces: Moraine Power Brakes—Delco hydraulic brake fluids, brake assemblies, master cylinders, wheel cylinders, and parts—Moraine friction materials—Moraine-400 and M-100 automotive engine bearings—self-lubricating bearings and porous metal filters—rolled bronze and bi-metal bushings.

*Another General Motors Value*

**Moraine Products**

Division of General Motors, Dayton, Ohio

## About SAE Members

Continued from page 116

**HORACE A. SHEPARD** has been made a director of Thompson Products, Inc. He joined the company in 1951 as vice-president and assistant to the president and general manager. In addition, he is staff vice-president for purchasing, accounting and industrial engineering. He also serves as group vice-president for all Thompson manufacturing operations.

Shepard came to the company from the Air Force where he was assistant deputy chief of staff for material at Air Force headquarters in Washington, and later director of procurement and engineering.

**JOHN F. CREAMER** and **FRED M. YOUNG** were elected new directors of the Automotive Old Timers at the annual meeting.

Creamer is president and treasurer of Wheels, Inc., N. Y. Young is president and general manager of Young Radiator Co., Racine, Wisc.

**WILLARD F. ROCKWELL** was elected to succeed himself as president, and **A. W. HERRINGTON** was re-elected as vice-president.

Rockwell serves as chairman of the board, Rockwell Spring & Axle Co., Coraopolis, Pa. Herrington is chairman of the board, Marmon-Herrington Co., Inc., Indianapolis, Ind.

Those elected to the executive committee include, Rockwell who is chairman, Herrington, **GEORGE A. MARTIN**, and **ALFRED REEVES.**

Martin is president, Town & Country Motors, Inc., and Truck Industries, Inc., Greenwich, Conn. Reeves serves as advisory vice-president, Automobile Mfrs. Association, N. Y.

**RUSSELL EDWARD LINNARD** is on a leave of absence from Phillips Petroleum Co., and is serving now as chief lubricant and asphalt coordinator in the Government Oil Refineries Administration of Iraq. He is now located in Baghdad.

At Phillips, Linnard served as supervisor, sales technical service, Bartlesville, Okla. He now is head of Coordinating Division of Lubricating Oil Refinery, Daura Refinery.

He has served actively in the SAE Mid-Michigan Section since he became a member of SAE in 1952.

**TROELS WARMING** has joined Ingersoll-Rand Co., Painted Post, N. Y. as senior engineer. Previously he was project engineer, Lycoming Division, Avco Mfg. Co., Stratford, Conn.

**MAURICE R. DENNY** has retired from manager of product information, General Motors Corp's Overseas Operations. Denny is now living in Clearwater, Fla., building a new home.

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## About SAE Members

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**HARLOW H. CURTICE**, president of General Motors Corp., has recently been presented with a plaque inscribed with the "blind" help-wanted ad he answered in 1914 that led to his present position.

The presentation was made in connection with the National Want Ad Week, March 17–23. The ad, offering a "fine opportunity" appeared in the Flint, Mich. Daily Journal. Curtice, then 20 years old and without a job, submitted an application.

The job was for a bookkeeper for the AC Spark Plug Co. which later became a division of GM. A year later Curtice became comptroller, and president in 1929. In 1933 he was called to Buick to revitalize that division, and 3 years later elected president of GM. The plaque was presented on behalf of more than 600 members of the Association of Newspaper Classified Advertising Managers.

**WHITMELL T. RISON** has been made vice-president of Thompson Products, Inc., Cleveland, Ohio. He joined Thompson in 1953 as assistant to the financial vice-president.

Previously he had been director, procurement and production at USAF headquarters in Washington. After his resignation from the Air Force, he was one of a group of business leaders selected to review America's foreign aid program in Italy. It was upon his return from the tour that he joined Thompson.

His education includes a B.S. degree in Civil Engineering from Virginia Military Institute, graduation from the aeronautic engineering course of the Air Corps Engineering School, and a M.B.A. degree from the Harvard School of Business Administration in 1947.

**ALBERT A. GARTHWAITE, JR.** has been named president of the Lee Rubber & Tire Corp., Conshohocken, Pa.

Garthwaite is a graduate of Yale University in mechanical engineering. His first position with the Lee Corp. was with the engineering department of the Republic Division. In 1945 he was assistant to the vice-president in charge of plants and in 1949 was elected a director of the Lee Corp. Four years later he was made vice-president and last year was named general manager of the tire plant facilities at Conshohocken.

**CHARLES D. MANHART** has moved from the Bendix Products Division, South Bend, Ind., to the central offices of the Bendix Aviation Corp., in Detroit, Mich. His post in South Bend was assistant to the vice-president. He has now become staff director, military and government sales.

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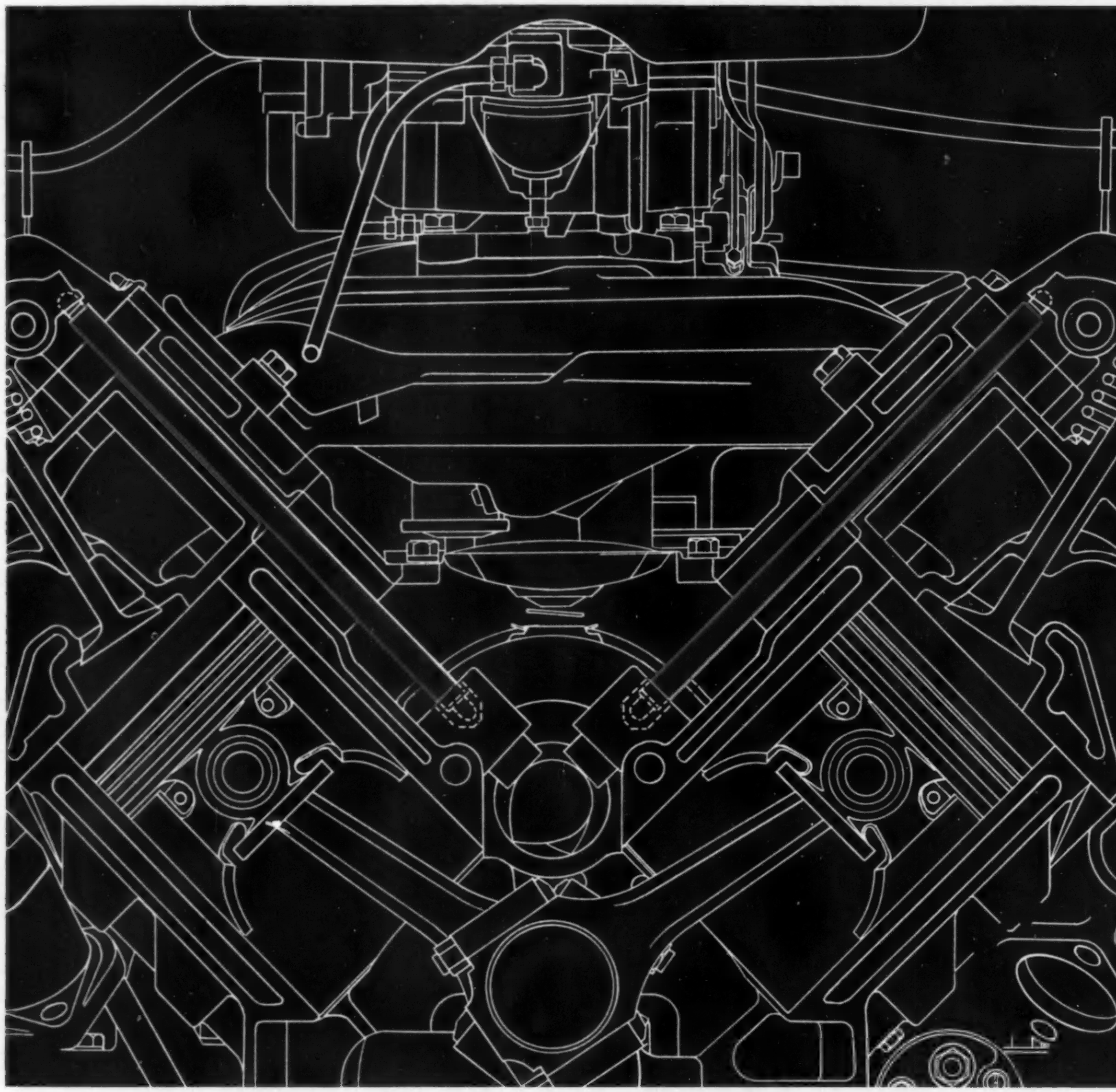
# Lightweight Bundy Tubing push rods



Long proved in heavy-duty truck engines, Bundy Tubing improves the performance of powerful V-8 engines by reducing cam load, increasing the efficiency of the entire valve train.

**BUNDYWELD IS DOUBLE-WALLED FROM A SINGLE STRIP**

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .


Bundyweld, double-walled and brazed through 360° of wall contact.


←

**NOTE** the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

## About SAE Members

Continued from page 120

**HAROLD S. VANCE**, member of the US Atomic Energy Commission, delivered a speech to the 1957 Nuclear Congress of the National Industrial Conference Board in Philadelphia. His remarks, presented on March 14, 1957, were entitled "Policy Aspects of Nuclear Power Development."

Before his affiliation with AEC, Vance was chairman of the executive committee, Studebaker-Packard Corp., South Bend, Ind. He has been a member of SAE since 1927.

**JAMES J. HOVORKA** has been named project engineer, Moraine Products Division, General Motors Corp., Dayton, Ohio. Previously he served as project engineer at the General Motors Proving Ground, Milford, Mich. In his new post he serves as liaison between Moraine and GM car manufacturing divisions.

**WILLIAM E. DAY**, formerly experimental engineer, Dana Corp., is now senior electrical engineer, engineering test section, Sikorsky Aircraft Division, United Aircraft Corp., Bridgeport.

He now heads a newly formed division of the test section, instrumentation research and development. The section group supports all ground, flight, and production testing, and handles all new instrumentation problems and development of new techniques. The scope of the problems covers the usual electrical output transducers and also branches into related fields that are vital to the advancement of helicopter engineering.

**ROBERT ALAN JEFFRIES** has become research assistant, Los Alamos Scientific Laboratory, Los Alamos, N. Mex. He is now working with studies of nuclear weapons systems.

His previous civilian duty was project engineer, Pontiac Motor Division, General Motors Corp. After leaving Pontiac in 1955, he served in the U. S. Air Force as aircraft maintenance officer at Ladd Air Force Base, Fairbanks, Alaska. In March of 1957 he became research assistant at Los Alamos.

**JAMES A. BECKETT** has been named data evaluation engineer, Thompson Products, Inc., TAPCO Division, Roanoke, Va. facility. Formerly he was research engineer for Ford Motor Co.

**DONALD F. COLLINS**, previously resident engineer, The Weatherhead Co., has joined Parker Aircraft Co. of Los Angeles as design engineer. He now is responsible for design and development of fluid line connections.

**GEORGE H. MICHAEL** has been construction machinery salesman, Allis-Chalmers Mfg. Co., Oakland, Calif. Formerly he was a territory manager for Minneapolis-Moline Co.

His job includes being representative on the Construction Machinery Division, promotion of all products, and improvement of dealer organization.

Other accomplishments of Michael include the writing and publication of two booklets. One is "Hidden Power," a booklet on salesmanship, and the other is "You're the Boss," on farm machinery business operation.

**ROBERT E. STREMMEL** has been named project engineer, Aviation Division, Development engineering department, Sunstrand Machine Tool Co., Rockford, Ill. Prior to this new post, Stremmel was missile liaison engineer, McDonnell Aircraft Corp., St. Louis, Mo.

**MARION FRANK STEINBERGER** has retired from the service of the Baltimore and Ohio Rairoad Co. where he has served as manager of highway transportation.

## About SAE Members

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**MORTIMER C. CROCKETT** has been named assistant to the vice-president and general sales manager for Kaiser Aluminum & Chemical Sales, Inc., Detroit, Mich. Prior to his new post, Crockett was automotive industry manager for the company.

**EDWARD MICHAEL NASH,** formerly principal engineer, General Electric Co., Evendale, Ohio, has been made aerodynamics designer for GE. He is now working for the Technical Military Planning Operation (TEMPO) at Santa Barbara, Calif.

**GEORGE E. MERKLE** has been named president of the Fiske Brothers Refining Co., Newark, N. J. Previously Merkle served as executive vice-president and general manager of Kiske Bros.



**ATTILIO R. SPICACCI** has announced his independent consulting engineer practice in Lancaster, Pa. He is specializing in ball and roller bearings, their manufacturing, designing, application, and marketing. Formerly, Spicacci was chief engineer, Bearings Co. of America Division, Federal Mogul Bower Corp., also of Lancaster.

**CHARLES O. McCUMBER** has joined Thompson Bros, Inc. of Cincinnati as service manager. Prior to this post he was service manager for Pemberton Cadillac Co., Toledo, Ohio. In his new position he supervises service and customer relations, conducts mechanical training classes, and adjusts owner complaints.

McCumber has been connected with automobile service for 35 years.

**ANDREW P. GREGG** has been named facilities group leader, Reaction Motors, Inc., Denville, N. J. He now supervises procurement, maintenance and operation of laboratory facilities: hydraulic, electric, pneumatic, environmental. Formerly Gregg was project engineer at Consolidated Diesel Electric Corp., Stamford, Conn.

**FRANK A. BEST** has retired as president and general manager of Standard Products of Canada, Windsor, Ontario, Can. He is now living in Southern Pines, N. C.

He had been in Canada since 1922, connected with Standard Products. During this time he was in charge of developments for the Canadian government in the war effort, many of which were used and manufactured by Standard Products. These included machine products, development and reduction of general costs, and motor trade of Canada.

For the future, Best is considering starting a Bureau of Research and Development on industrial, mechanical, and ceramic developments from N. C. His job in Canada has provided experience in these fields. He is also interested in a universal communications system, presently his hobby, which he believes will mean an up-to-date version of Braille.

**BURKE M. HYDE, JR.** has been made staff of operations manager for New Process Gear Co. of Syracuse, N. Y. Previously he was Washington representative for Chrysler Missile Operations, Chrysler Corp.

**CHARLES F. GRAY, JR.,** formerly quality control engineer, Studebaker-Packard Corp., has been named quality control supervisor for Utica-Bend Corp., South Bend, Ind.

**FRANK P. WATSON** is now preliminary designer, Hiller Helicopters, Palo Alto, Calif. Prior to his new post he was designer, mechanisms, Northrop Aircraft Inc., Hawthorne, Calif.

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## About SAE Members

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**JOSEPH R. RODA** has been named marketing manager, European vehicles and tractors, Ford International Division, export sales operations, Jersey City, N. J. He is now responsible for the development of all European vehicles produced by Ford manufacturing activities in England, Germany, and France. In addition, he is in charge of Ford American and British tractor business in all areas served by export sales operations, Ford International Division. This includes Latin America, Middle East, and the Far East.

In January, 1956, his position changed from general manager of the Ford branch in Buenos Aires, Argentina, to assistant regional director for the Mediterranean and the Middle East areas, with headquarters in Dearborn, Mich. In February of 1957 he was named marketing manager.

**FRANK B. TIPTON** is now engaged in his own business as a consultant engineer, Del Mar, Calif. Formerly he was chief engineer, Gilfillan Bros., Inc., Aircraft Mfg. Division, Los Angeles, Calif.

**ROY ROBERTSON BORLAND** has been named design draftsman, Central Engineering, Chrysler Corp. Previously he was a design draftsman with Gray Marine Motors, Detroit, Mich.

**ARTHUR E. SMITH**, formerly assistant engineering manager, has been made engineering manager of Pratt & Whitney Aircraft Division, United Aircraft Corp., East Hartford, Conn.

**HARRY THEODORE BRATT** has become vice-president of engineering, American Hoist Pacific Co., Seattle, Wash. Prior to this position he was assistant chief engineer, American Hoist and Derrick Co., St. Paul, Minn. American Hoist Pacific Co. is a subsidiary of the American Hoist and Derrick Co.

Bratt is working with general engineering and estimating, planning operations, standards, and personnel relations.

**ARTHUR CHARLES COCAGNE** has been named vice-president—field engineering, Telecomputing Corp., Van Nuys, Calif. Previously he was director of field engineering for Wm. R. Whittaker Co., parent company of Telecomputing.

**JAMES F. BOURQUIN** has been made works manager, Estate Division, Whirlpool Corp., Hamilton, Ohio. He is now in charge of all manufacturing operations at the Hamilton plant of Whirlpool. Previously he was assistant works manager, Reo Motors, Lansing, Mich.

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Revolutionary *Filtronic*® Carburetor Air Filter

# Product of FRAM

## Pioneering Research

ONLY FRAM CARBURETOR AIR FILTERS HAVE THIS EXCLUSIVE PATENTED BUILT-IN GASKET!

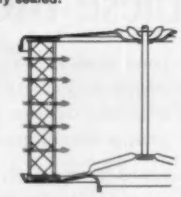
Researched in the FRAM Dust Tunnel in Dexter, Michigan—proved by thousands of miles of dust-laden driving—now original equipment on nearly 50% of 1957 cars. That's the story of the FRAM *Filtronic* Type Carburetor Air Filter that *obsoletes all other air filter types.* Here's why:

Only FRAM features the patented built-in gasket shown above. This FRAM patented design absolutely prevents by-passing of dirty air: eliminates all of the defects found in other types of sealing—such as metal to metal, metal to cork or compound gaskets and metal beads pressed against a flat plastisol face. Unless these types of cartridges are replaced after servicing, in *exactly* the same position, they leak dust and dirt.

FRAM engineers designed the exclusive FRAM patented built-in gasket as an integral part of the end seal. It can never leak dirt-laden air—no matter how often it is serviced! Add these other FRAM advantages: 99.+% efficiency, easy cartridge replacement and you'll know why the FRAM *Filtronic* Carburetor Air Filter Cartridge is the finest on the market. A FRAM representative will be happy to give you full details including research information. Drop a line today to FRAM CORPORATION, Providence 16, Rhode Island, or FRAM Canada Ltd., Stratford, Ontario.

**Only FRAM can make these statements!**

FRAM patented built-in gasket forms a perfect air-tight seal—no matter how often the cartridge is serviced, the unit is always perfectly sealed.



ALL air must pass through the filtering media. Once locked in place under slight pressure, this built-in gasket provides an absolute bond with the housing case.

FRAM Corp., Providence 16, R. I. • Fram Canada Ltd., Stratford, Ont.

**New FRAM "Filtronic" Carburetor Air Filter original equipment on these 1957 engines:**

Continental • Ford • Lincoln • Mercury • Thunderbird • Turnpike Cruiser • Packard • Studebaker • American LaFrance • Autocar • Clark • Cummins • Diamond T • Divco • Continental Motors • General Supply • Harley Davidson • Lycoming • Reo • Sheppard

FRAM OFFERS A COMPLETE LINE OF REPLACEMENTS FOR OTHER CARS EQUIPPED WITH A FILTRONIC TYPE CARBURETOR AIR FILTER: Imperial • Chrysler • Dodge • DeSoto • Plymouth

## About SAE Members

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**HOWARD A. GRANT**, formerly project design engineer, General Electric Co., Syracuse, N. Y., has been transferred to mechanical design engineer, Tempe, Ariz., for the company. He has been relocated to help establish the new computer department.

**GEORGE WILLIAM REED** has become president of the George W. Reed Co., Prospectville, Pa. Formerly Reed was eastern regional sales manager, Globe Hoist Co., Philadelphia, Pa.

The George W. Reed Co. is a manufacturers' representative company in automotive testing and service equipment.

**T. C. Du MOND**, formerly editor of *Materials and Methods*, has joined J. M. Hickerson Inc., N. Y., as director of public relations.



**C. FAYETTE TAYLOR**, professor of Automotive Engineering and director of the Sloan Laboratories, and **A. R. ROJOWSKI**, associate professor Mechanical Engineering, have announced a 2-week course in Internal Combustion Engines at MIT. The course is offered during the MIT 1957 summer session. It will be conducted by the staff of the Sloan Automotive Laboratories.

The course will emphasize basic engine theory and the analytical approach, as they apply to the solution of performance and design problems and to planning and control of experimental and development programs. The following topics will be included: engine capacity, engine efficiency, engine design, and laboratory techniques and instrumentation. This course is offered especially for the younger engineers in industry and for college teachers in this field.

**WILLIAM E. JOLIN, JR.**, formerly development engineer, Weatherhead Co., Antwerp, Ohio, is now with Stratoflex, Inc., of Fort Worth, Tex., as a project engineer.

**ROBERT NELSON HAGARTY** has joined the Electric Boat Division of General Dynamics Corp., Groton, Conn. Previously he was design engineer, Public Service Coordinated Transport, Newark, N. J.

**DAVID STUART CRAVEN**, formerly superintendent of maintenance, Louisiana Industries, Inc., New Orleans, La., is now superintendent of equipment, Replogle Equipment Co., Circleville, Ohio.

**WILLIAM S. KASKA** has been made sales branch manager in the Dallas, Tex. area for Titeflex, Inc. Prior to his relocation he was sales engineer in the Newark, N. J., district office.

**PAUL F. ALLMENDINGER** has joined Stewart-Warner Corp. of Chicago, Ill. as assistant chief engineer in the Instrument Division. He now has general supervision in the engineering activity of the division.

Formerly he was chief engineer, Magneto Division, Fairbanks Morse & Co., Beloit, Wis.

Allmendinger has served on the SAE Milwaukee Section Governing Board.

**JOHN F. McCARTHY** has joined the Ford Division of the Ford Motor Co. in purchasing. Formerly he was manager, production control, Hoover Ball & Bearing Co., Ann Arbor, Mich.

**WALTER C. ZETYE** has been made senior project engineer, chassis, Chevrolet Motor Division, Chevrolet Engineering Center, General Motors Corp. Previously he was senior designer, chassis. Continued on page 133

# making history or moving mountains...

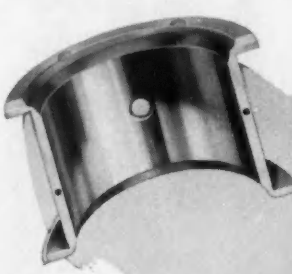
## BOHN parts . . . always dependable


Photo Courtesy Warner Brothers' "*Spirit of St. Louis*"

***1927*** Solo . . . New York to Paris . . . 33½ hours . . . non-stop. Lindbergh's epic achievement focused world attention on an infant industry . . . and aviation surged into a new era of progress.

BOHN BEARINGS, in the 225 H.P., 9 cylinder engine, functioned unfailingly throughout this history making flight.

***1957*** Today, 30 years later, Bohn still makes dependable bearings . . . still pioneers in the development of better parts for all industry. This mammoth crawler tractor moves mountains . . . does the *big jobs easily.* Bohn *aluminum-on-steel bearings* and *heavy-duty aluminum pistons* are vital parts of the 320 H.P., diesel engine powering this 30-ton giant.



***Bohn Aluminum-On-Steel Bearings . . .***

available in a wide range of thicknesses. Recommended for light or heavy-duty applications. High fatigue resistance, handle loads up to 10,000 psi. Non-corrosive, usable with all types of shafts.

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give positive bond with iron or nickel alloy inserts. Improve engine performance by eliminating top ring-groove wear and reducing oil consumption.

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COMPLETE RANGE OF SIZES AND TYPES
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One piece designs • Spider Types • Variable Spaced Blades • Swept Flo Tips.
Steel, aluminum and non-corrosive materials.
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DESIGNS AND APPLICATIONS FOR ALL MOBILE AND STATIONARY EQUIPMENT
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## About SAE Members

Continued from page 130

**THOMAS W. HEAD** has been made supervising engineer, advanced power plants section, research department, Caterpillar Tractor Co., Peoria, Ill. He now supervises a group of engineers and technicians working on advanced powerplant design and development. Formerly Head was research engineer for Caterpillar.

Head has been a member of SAE since 1953 and now serves as field editor of the Central Illinois Section.

**CHARLES L. DRISCOLL** has been named chief engineer, Cleveland Formgrader Co., Avon, Ohio. Previously he was manager of the Cleveland office for the Resistoflex Corp. of Belleville, N. J.

**EMBREE M. KENNEDY** has joined the new truck manufacturing program of General Motors Corp. of Brasil as executive engineer. Previously he was product engineer, GM of Mexico.

**FRANK J. SARGENT** has been named to the newly created position of manager, industrial sales in the national accounts department, Ashland Oil and Refining Co., Ashland, Ky., and its affiliated companies.

For the past several years Sargent has held posts with Allied Oil Co. in Cleveland, an affiliate of Ashland. Prior to his work with Allied, he had spent over 15 years with National Refining Co. in various sales posts, including industrial sales manager.

**JEAN C. DUBUISSON,** formerly flight test engineer A, Radioplane, Holloman Air Force Base, New Mexico, has been named design engineer for Aerojet-General, Azusa, Calif.

**DR. PAUL ZIVKOVICK** has been named executive vice-president of Hart Metal Products Corp., Elkhart, Ind. Formerly he was vice-president, also of Hart Metal Products.

**IRVIN E. McWETHY** has been named division manager, The Murray Corp. of America, Cincinnati, Ohio. Formerly he was manager of the development engineering department. Prior to joining the Murray Corp., he was with Hotpoint Co. of Chicago and later with Admiral Corp. of Galesburg, Ill.

**JERRY SZTYKIEL,** formerly truck chassis engineer, Chrysler Corp., has been made senior engineer for truck engineering for Chrysler. In the new post he heads the engineering section handling rear axles, service brakes, propeller shafts, wheels and related parts.

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## About SAE Members

Continued from page 133

**CHARLES GREENWOOD MOORE, JR.,** has been named field test engineer, General Electric Co., missile and ordnance systems department, Philadelphia, Pa. Prior to this post, Moore was mechanical engineering assistant, U. S. Army, Quality Assurance Technical Agency, Chemical Corp., Army Chemical Center, Edgewood, Md.

**RICHARD ROLAND RISS II** has been named head of the Colorado Petroleum Research Laboratories Inc., Denver, Colo. In addition, Riss serves as president of Champion Mines Co., also of Denver.

**ALFRED NOAH CAVE** has joined Boeing Airplane Co. as associate engineer. Prior to this post he was process engineer, Allison Division, General Motors Corp., Indianapolis, Ind.

Cave has been assigned to the "Bomarc Systems" coordinator who is in charge of guided missile operations at Cape Camaveral, Fla.



**ANDREW T. BROWNE,** formerly manager, Industrial Engineering Division, has been named chief engineer, Globe Hoist Co., Philadelphia, Pa. He is now in charge of product design and development.

Browne has been active in the Philadelphia Section of SAE, serving as chairman in 1956–1957.

**OTHA HOWARD VAUGHAN, JR.** has been made aeronautical research engineer, Army Ballistic Missile Agency, Huntsville, Ala. He is connected with the aero-thermodynamics, flight evaluation unit doing work in measurements during missile flight for correlation of calculated data. Previously he was project engineer, project staff, Eglin Air Force Base, Fla.

**ROBERT E. DAY** has been named chief project engineer, metal products, Solar Aircraft Co., San Diego, Calif. Prior to this appointment, Day was project engineer for several Solar afterburner development projects and a gas turbine engine project. He has also worked as a research engineer with Solar.

Before joining Solar in 1946, Day worked with General Electric Co. as research and development engineer.

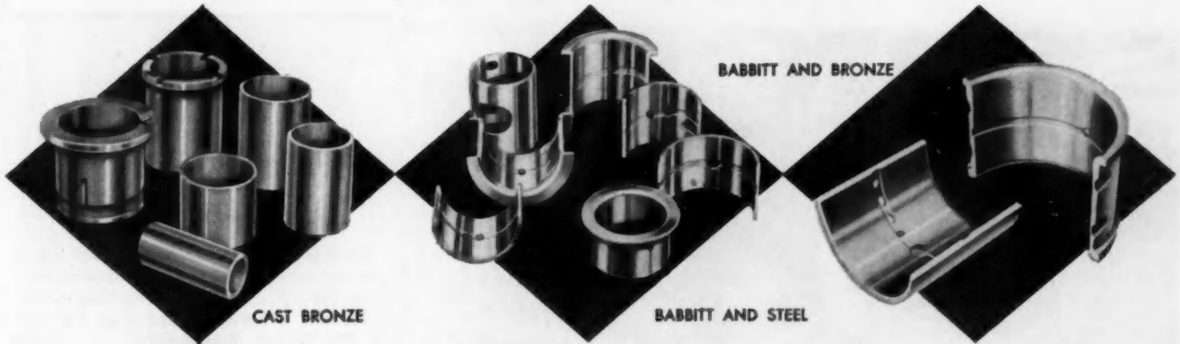
**HAROLD W. SEYLE** has been named product engineer, Summers Gyroscope Co., Santa Monica, Calif. Previously he was designer for Aerophysics development Co., Santa Barbara. Seyle has engineering responsibility on the remote altitude indicator produced by Summers for the USN and USAF.

**CHARLES COOK, JR.** has been made responsible for engineering and production liaison with Clark Equipment International, Clark Equipment Co. He will handle all overseas licensees on behalf of all the company's products. He has been product engineer with Clark's Industrial Truck Division for the past four years and was previously associated in production and engineering positions with Paramount Engineering, International Harvester, Continental Motors Corp. and Fuller Mfg. Co.

**ERVIN E. SCHIESEL** has been named president of Arrowhead Associates, Meriden, Conn. Formerly, Schiesel was vice-president, engineering and sales, Mattatuck Mfg. Co. of Waterbury, Conn.

**BERNARD WILLIAM WORTELBOER** has resigned as assistant chief engineer at Universal Friction Materials Co. of Kendallville, Ind. He is now connected with Wortelboer's Automotive Supplies, Muskegon, Mich.

**EARLIE S. EVERHART, JR.** has joined the Mack Truck, Inc. operation in Sidney, Ohio as fire apparatus engineer. Previously he held the same position at the Mack operation in Allentown, Pa.





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## Obituaries

### DEXTER S. KIMBALL, JR.

Dexter S. Kimball, Jr., 1957 SAE vice-president for Production Activity, died on April 28. He was vice-president and general manager of Bendix-Westinghouse Automotive Air Brake Co. He was 50 years of age.

Kimball was a leader in many civic and educational fields as well as one of the middle west's outstanding executives. He was trained as an engineer and retained his interest in engineering ideas even after moving into administrative posts.

In addition to his SAE activities, Kimball was on the Advisory Board of the International Accountants Society, a member of the American Society of Mechanical Engineers, and the Cornell Club of New York. He also served as a trustee of Cornell University.

Kimball's civic activities in the Elyria, Ohio, area included: director of Elyria Memorial Hospital, president of United Fund of Greater Elyria, trustee of Elyria Library, vice-president of the Firelands Council, Boy Scouts, president of the Elyria Chamber of Commerce, director of the Y. M. C. A., and the Community Chest.

He was responsible for the establishment of the Junior Achievement program in the Elyria area, was a past-president of Elyria Kiwanis, and a trustee of the Congregational Church.

Kimball entered Stanford University in 1922, transferring to Cornell University in 1923, where he received a B.S. degree in mechanical engineering in 1927 and a M.S. degree in 1928.

In 1928, he joined General Motors Corp. as a machine operator and subsequently advanced to supervisor. He returned to Cornell in 1931 as assistant professor of industrial engineering. In 1934, he went to North American Aviation Corp. as production engineer and later joined B. F. Goodrich Co. as planning supervisor. He was production manager for General Household Utilities Co. of Chicago in 1937 and 1938. He then went to the Ansco Division of General Aniline and Film Corp. in Binghamton, where, during World War II, he was plant manager in charge of instrument production for the Armed Services.

Kimball became factory manager at Bendix-Westinghouse in 1945. He was later made general manager and in 1953 was named vice-president and a director of the company.

With his father, he was co-author of the text "Principles of Industrial Organization." He also wrote a number of texts for the International Correspondence School and developed various training programs for industry during World War II.

Continued on page 139

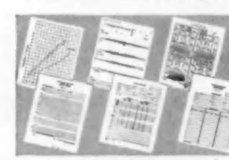
# You can't BUY it until we TRY it

Few engineers have had the pleasure of seeing a new design spring into production without bugs. Many have been wounded by bugs that survived exhaustive lab tests, and emerged in production quantities on the road. American Brakeblok's on-the-road fleet testing prevents this painful experience.

To insure complete design confirmation, pilot production samples are subjected to field service conditions in cars and trucks completely instrumented to furnish comprehensive test reports. In addition, American Brakeblok's nationwide field service engineering is available to assist in your own evaluations.

For a complete picture of American Brakeblok service, send for the 20-page brochure, "Taming Dynamics with Engineered Friction." Good reading.

**Complete Test Data Confirms New Designs**

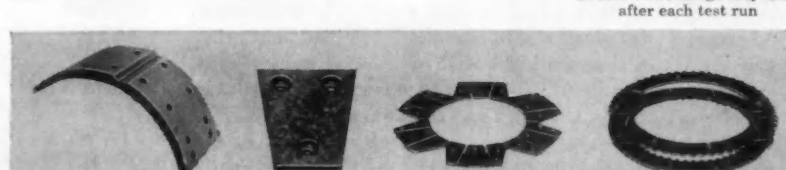


Sample data pages prepared for customers from tests

Drums and linings inspected after each test run

American REG. U. S. PAT. OFF. Brakeblok

FRICTION MATERIALS



Asbestos-based friction materials

Sintered metal friction materials

AMERICAN Brake Shoe COMPANY

**AMERICAN BRAKEBLOK DIVISION**

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## Obituaries

Continued from page 136

### PAUL DE KUZMIK

Paul de Kuzmik, technical adviser, Paniar do Brasil, Rio de Janiero, died Oct. 21, 1956.

He was born in Budapest, Hungary, in 1894 and received a degree in technical engineering from the Technical University in Budapest. He worked as an engineer in Budapest until 1925 when he came to the United States and worked in various engineering capacities in Chicago. He was affiliated with the Western Electric Co., Super Diesel Tractor Corp., Cline Electric Co., Electrolux Inc., and Stutz Motor Car Co.

In 1929 he joined the Pan American Airways Inc. as division engineer and in 1933 relocated in Rio de Janerio as engineer with Cargo of Maintenance, PAA. For ten years he was maintenance engineer in the Brazilian Division and Paniar do Brazil of PAA. In 1945 he was made special assistant to the president and in 1953 technical adviser to the general manager.

De Kuzmik had been a member of SAE for 26 years, joining in 1931.

### FRANK W. SZANTO

Frank W. Szanto, project engineer, Continental Motor Corp., Detroit, died on Sept. 23, 1956.

Szanto was born in 1927 and was graduated from the University of Michigan with a B.S. degree in mechanical engineering. In 1951 he started working as an engineer at Chase Brass and Copper Co. in Waterbury, Conn. In 1952 he was an engineer at Bridgeport Thermostat Division of Robertshaw-Fulton Controls Co., and subsequently was named to product and design engineering at American Locomotive, Schenectady, N. Y.

In 1954 he joined Continental Motors as an engineer working on powerplant layout and was later named project engineer.

### FRANCIS A. MALLERY

Francis A. Mallery, vice-president and general manager of Furlow-Cote, Inc., Chattanooga, Tenn., died in January. Mallery was born in 1907 and started working in the Ethyl department of the Louisiana Oil Refining Corp. From 1933 to 1935 he served as assistant manager of the Midland Petroleum Co. and Barnesdale Oil Co. He joined the Wray Dickens Co. in 1936 and became a salesman in the Capital City Ford Co. in 1940 and 1946, interrupted by military service.

In 1947 he was named vice-president and general manager of the Furlow-Cote, Inc., working with sales and lease of trucks and cars.

Continued on page 141

## Obituaries

Continued from page 139

**E. WALDO STEIN**

E. Waldo Stein, member of SAE since 1942 and sales engineer at Firestone Tire and Rubber Co., died Nov. 16, 1956.

He was born in Los Angeles in 1891 and from 1921 to 1938 worked as development engineer with Firestone. He was then named sales engineer dealing with engineering contacts and tire development on new models. In 1940 he was dealing with field engineering contacts at military posts and was, in 1942, named military field engineer. From 1952 until retirement he served as sales engineer in the Defense Production Division of Firestone.

**FORREST H. KANE**

Forrest H. Kane, retired executive engineer, died Jan. 28, 1957.

Kane was born in 1898 and joined SAE in 1919. He worked as chief draftsman, Oakland Motor Car Co., Pontiac, Mich. before being named to the engineering department at Oakland Motor Car Co. In 1922 he was made assistant engineer and, two years later, technical engineer.

In 1935 he joined the Pontiac Motor Co. as assistant to the chief engineer, and was made executive engineer in 1941 before retirement.

**FRANK RYCAMBER**

Frank Rycamber, general foreman, inspector, Cadillac Motor Car Division, General Motors Corp., Detroit, died Dec. 24, 1956.

He was born in 1911 in Brooklyn, N. Y. and attended the University of Detroit from 1934 to 1936. Rycamber had been with Cadillac since 1927 when he started as an inspector of machine and engine parts. In 1939 he was named foreman of inspection, superintendent in 1940 and general foreman of inspection in 1946.

Five years later he was made general foreman of production and from 1953 had been located at the inspection central office as general foreman.

**GEORGE W. HOBSON**

George W. Hobson, member of SAE since 1945, died recently.

Hobson was born in 1915 in Cleveland, Ohio and was graduated from Case School of Applied Science, Cleveland, in 1937 with a B.S. in mechanical engineering. He started working as an engineer at American Mono Rail Co., Cleveland. From 1939 to 1942 he was an engineer at the Stinson Aircraft Corp., Wayne, Mich., and at Vultee Aircraft Corp. of Nashville, Tenn.

He joined Goodyear Aircraft Corp., Akron, Ohio, and served as a liaison—salvage engineer and subsequently field engineer. Hobson was with Goodyear from 1942 to 1949.

He then was named aero development control engineer, U. S. Army Air Forces, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio. Following this he was named aero resident, development and design engineer, USAF.

**GLEN G. HAYS**

Glen G. Hays, president and general manager of Bearing and Rim Supply Co., Spokane, Wash., died recently.

He was born in Endicott, Wash. in 1906 and started working for Bearing and Rim Supply Co. in 1926. He was made assistant manager in 1945 and named president in 1952.

Hays became a member of SAE in 1945.

Continued on page 142

## Obituaries

Continued from page 141

### WILLIAM A. SILER

William A. Siler, retired engineer draftsman, Delco Remy Division, General Motors Corp., Anderson, Ind., died Jan. 8, 1957.

Siler was born in Albany, N. Y. in 1893 and worked as a designer until 1917 at General Electric, Schenectady, N. Y.; Remington Arms, Bridgeport, Conn.; and Westinghouse Electric and Mfg. Co., Pittsburgh, Pa.

From 1919 to 1925 he worked as mechanical engineer for Westinghouse in Pittsburgh and in Springfield, Mass. In 1925 he joined Delco Remy Division as chief draftsman and was named engineer draftsman in 1946.

### W. DEAN BURTON

W. Dean Burton, construction engineer, died recently. Burton had been a member of SAE for 40 years.

He was born in 1882 and worked as a draftsman until becoming head designer with the Union Pacific Railroad, Omaha, Neb., in 1904. Five years later he joined McKeen Motor Car Co. of Omaha as chief draftsman and was later made mechanical engineer.

In 1920 he became chief engineer, U. S. A. Balloon School at Fort Omaha. Three years later he was named aeronautical mechanical engineer, U. S. Army, Air Service, McCook Field, Dayton, Ohio. Burton relocated in Chicago in 1928 where he was chief engineer at the Steamotor Co. and Combustioneer Inc.

In 1935 he worked at the California Institute of Technology Astrophysical Laboratory in Pasadena and in three years was named mechanical engineer at the astrophysical observatory of the Institute.

He was named mechanical engineer, Western Gear Works, Lynwood, Calif. in 1944 and chief mechanical engineer at Consolidated Steel Corp., Maywood, Calif., in 1947.

Burton served, from 1950 to 1953, as chief engineer and senior mechanical engineer at Consolidated-Western Steel Corp., and Severdrup and Parcel Inc., respectively. In 1953 he became a construction engineer.

### PAUL E. GERY

Paul E. Gery, section supervisor, quality control department, Engineering and Foundry Division, Ford Motor Co., died Jan. 16, 1957.

Gery joined Buick Motor Co. as a test engineer in 1931. Three years later he became a project engineer at General Motors Corp.'s Research Laboratory.

He subsequently served as assistant chief engineer at Jacobs Aircraft Engine Co.; product engineer at Detroit Diesel Engineering Division of GM; product engineer at Borg-Warner Corp.; and sales and development engineer, Aluminum Alloys Corp.

In 1947, Gery was named president and general manager of the National Casting and Mfg. Co., Inc. Later he joined Willys-Overland Motors, Inc. as assistant auto powerplant engineer.

In 1952 he became technical assistant to the chief engineer, gas turbine plant, Mercury Division, Ford Motor Co. He was then made assistant manager, quality control, and subsequently, section supervisor.

### J. G. MOXEY, SR.

J. G. Moxey, Sr., transportation engineer, died recently. He had been a member of SAE since 1933.

He was born in Philadelphia in 1886 and started working as a system operator in 1909 at the Philadelphia Electric Co. He was with them until 1912 when he joined the Atlantic Refining Co. as supervisor of motor equipment. In 1932 he joined Sun Oil Co. as transportation engineer and later became president of the Petroleum Truck Service, Inc., Upper Darby, Pa.

In 1940 he served with the Automotive Club of Philadelphia as director of public relations and in 1944 was named operations officer, Transportation Division, staff headquarters, Fourth Naval District, Navy Yard, Philadelphia.

Since 1945 he had served as both an automotive and transportation engineer.

### HARRY A. TARANTOUS

Harry A. Tarantous, industrial editor, McCann-Erickson, Inc., died recently. He had been a member of SAE since 1919.

He was born in 1889 in New York City and began working in various departments of Packard Shops in Detroit. He worked for a short time in the experimental room of Brush Runabout Co. before joining the editorial staff of *Motor Age*, Chicago. In 1920 he was named managing editor of *Motor*, International Magazine Co., N. Y.

Tarantous was made special representative, Macfadden Publications, Inc. of N. Y. and, two years later, advertising manager of *Automotive Daily News*. In 1928 he became business manager, and subsequently vice-president for the publication. He also served as special representative for the *New York Daily News* before joining McCann-Erickson.

He had been with McCann-Erickson since 1936, starting as an account executive and writer, and becoming industrial editor in 1940.

(1) Imagine a room kept spotlessly clean . . . where temperature and humidity never vary . . . where the air is filtered, and workers are provided with special lint-free clothing. These are the conditions under which the manufacture of Aeroquip 666 Hose starts, with a mixture of exact amounts of sifted Teflon powder, lubricant and coloring.

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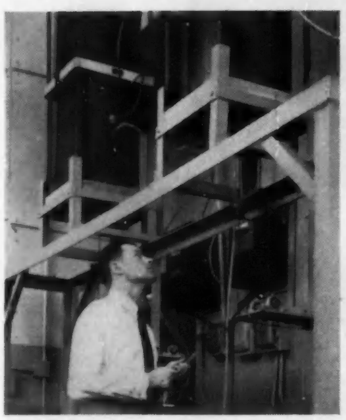
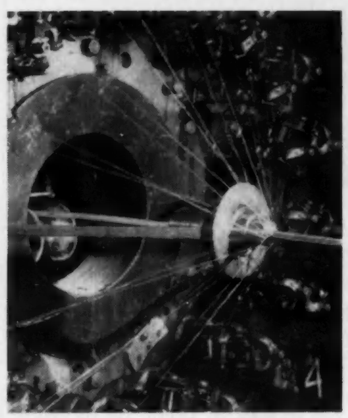


(2) After proper aging, the mixture is formed into a "cake" which is fed into an extrusion press and emerges as tubing. Wall thickness, diameter and concentricity are carefully controlled. The tube of Teflon passes through electric ovens (pictured above) where it is sintered and assumes the characteristic "Aeroquip red" color.

*DuPont Tradename for its Tetrafluoroethylene Resin



(3) After inspection, the tube moves to the braiding machine where it is reinforced with stainless steel wire. The closely controlled method used results in exceptionally tight, positive braiding . . . a distinctive Aeroquip feature. After passing final tests, the hose is identified as "Aeroquip 666", your assurance of unequalled quality in hose lines made of Teflon.

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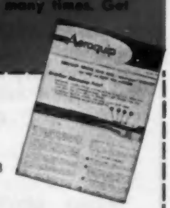


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Gentlemen:

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## Obituaries

Continued from page 142

### CHARLES E. STONE

Charles E. Stone, president of the Interstate Drop Forge Co., Milwaukee, Wis., died Dec. 20, 1956.

Stone was born in 1887 in Portland, Mich. and received a B.S. degree in mechanical engineering from the University of Michigan in 1910. He started his career working as an engineering apprentice for the Foos Gas Engine Co. of Springfield, Ohio, was named mechanical engineer in 1911, and purchasing agent in 1913.

In 1918 he joined the Chain Belt Co. of Milwaukee as purchasing agent and was named assistant to the president in 1921. He was made vice-president of the Interstate Drop Forge Co. in 1926 and president in 1928.

### WALTER L. NEWSOM

Walter L. Newsom, sales engineer, Griswold Carburetor Co., Wayne, Pa., died Dec. 19, 1956.

He was born in 1888 in Columbus, Ohio, and started working as a service manager at Manwaring and Goodman, Philadelphia, Pa. in 1916. For the following four years he was self-employed in Denver, Colo., joining Philadelphia Electric Mfg. Co. in 1926. He served as an engineer there and also in Cities Service Oil Co. of Pa.

In 1936 he joined the Petrol Corp., Instrument Motor Testing, Philadelphia, affiliated with Cities Service Oil Co. He remained there until becoming sales engineer at Griswold.

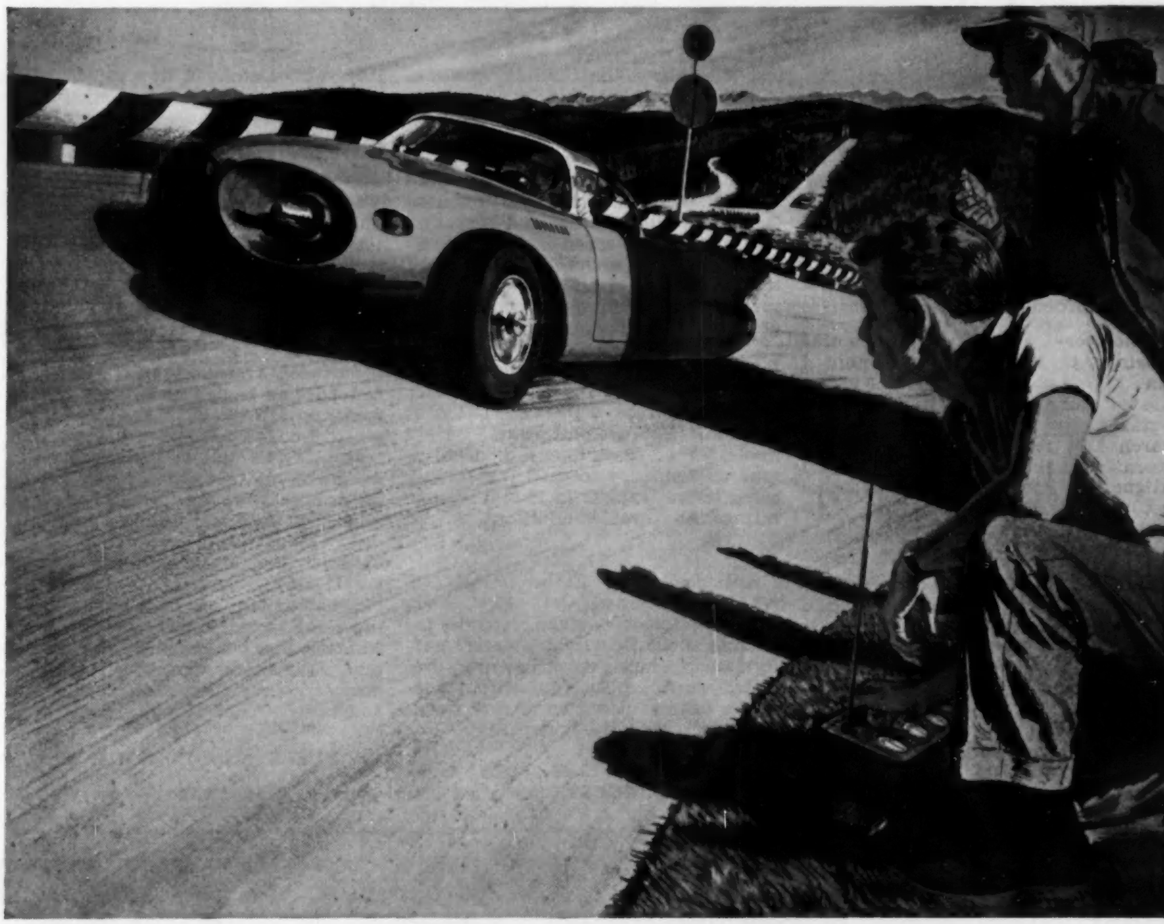
### CHRISTIAN PRETZ

Christian Pretz, vice-president, chairman, executive committee, Durham Mfg. Co., South Bend, Ind., died recently.

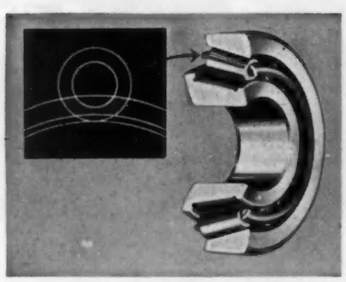
He was born in 1874 and became a member of SAE in 1911. He served as vice-president and factory manager, superintendent, and general foreman at Olds Motors Works until 1911 when he was named vice-president and factory manager, Maxwell-Briscoe Motor Co.

In 1914 he joined Studebaker Corp., Detroit, as general supervisor and six years later became production manager. Thirteen years later he was made works manager, then production manager, and subsequently general production manager, and chief engineer, Truck Division, Studebaker.

In 1938 he was named factory manager of the Truck Division and, in 1943, assistant to the vice-president of the Aviation Division. It was in 1946 when he first joined Durham Mfg. Co. as vice-president, chairman, executive committee.



# Tomorrow's "dream" is our job today!



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*As shown by the gray area above, the higher flange provides a large two-zone contact area for the roller heads. This greatly reduces wear—practically eliminates "end play". Larger oil groove provides positive lubrication.*

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BOWER ROLLER BEARINGS

## Briefs of SAE PAPERS

Continued from page 101

counted to determine rates of wear.

**Laboratory Study of Automotive Bearings, G. F. BONNER.** Presented Jan., 1957, 8 p. Investigation of vibration of rolling contact bearings, undertaken by Ford Engineering Research Div, revealed relationship between vibration, surface finish, and fatigue life; specially designed fatigue test machine, instruments and techniques used; study of sleeve type bearings.

**Valve Train Wear as Affected by Metallurgy, Driving Conditions, and Lubricants, V. AYRES, J. B. BIDWELL, A. C. PILGER, Jr., R. K. WILLIAMS.** Presented Jan., 1957, 15 p. Results of field survey of CLR Camshaft and Valve Tappet Wear Group; data submitted by 30 laboratories on 295 cars having variety of camshaft and tappet metallurgy design combinations and operated on four different test oils show that oil composition, metallurgy and design have independent and related effects in controlling degree of wear, scuffing, and spalling.

**Timken Wide-Range Two-Speed Axle, N. R. BROWNYER.** Presented Oct., 1956, 7 p. Studies and charts on wide-range two-speed axle in combination with short-step five-speed transmission; advantages over ten-speed transmission in performance and design.

**New Engines Demand Tailored Spark Plugs, RICHARD C. TEASEL.** Presented Oct., 1956, 7 p. Description of electronic test equipment used as aid in design of spark plugs to decrease fouling tendency caused by higher compression ratios, increased octane ratings, and greater additions of lead to fuels.

**Automobiles of Future, CARL S. RYAN.** Presented Oct., 1956, 4 p. Future automobile styling trends, including height, weight, power performance; new developments predicted such as fuel injection, free-piston engines based on engine trends and experimentally-built cars.

**Hauling Huge Loads, 1000 Arctic Miles, L. E. BURGESS.** Presented Oct., 1956, 4 p. Details of how vehicle used in mining and heavy construction work was modiged to enable it to carry large payloads over 1000 miles of Arctic territory.

**Mechanic Education and Training, AMOS E. NEYHART.** Presented Oct., 1956, 7 p. Discussion of mechanic, training, shop, supervisor, and the role that each plays in developing good mechanics; suggestions offered as steps to more and better mechanics.

**Surface Transportability and Its Influence on Design of Military Equipment, SUMNER MEISELMAN.** Presented Oct., 1956, 20 p. Surface transportability of military items influences design of military equipment; including requirements for normal, semiregulated, regulated, and special shipments.

**Design for Maintenance, GUSTAV E. HEIBER.** Presented Oct., 1956, 4 p. Discussion of bus maintenance problems, specificially problems of windshield wiper, engine, cooling system, carburetor, muffler, steering geometry, tires, suspension, brakes, and body.

### FUELS AND LUBRICANTS

**Spark Plug Fouling—Survey—Test**

Procedures—Fuel Factors, **C. A. HALL, R. C. BEAUBIER, E. C. MARCKWARDT, R. L. COURTNEY.** Presented Jan., 1957, 14 p. Results of field survey conducted to determine amount of spark plug fouling occurring, how it affects car operation, and whether car owners complain about spark plug fouling; cars selected were 1955 and 1956 models all of which had verhead valve V-8 engines and automatic transmissions; procedures and instrumentation; fuel factors; diagrams.

**Combustion Chamber Geometry and Fuel Utilization, J. C. HUGHES.** Presented Jan., 1957, 34 p. Question whether further increases in compression ratio are economically valid by gains in power and efficiency; compression ratios from 4 : 1 to 16 : 1 were investigated in special single-cyl engine, as well as quench or squish areas from 0 to 50% piston coverage; test equipment and procedure; results show that benefist of increasing compression ratio are subject to law of diminishing returns.

**Use of Temperature-Density for Measuring Antiknock Quality, B. R. SIEGEL.** Presented Jan., 1957, 48 p. In tests at Sinclair Research Laboratories it is shown that limitations of existing test methods can be eliminated by operating engine at constant fuel-air ratio, peak power spark and by using manifold air pressure to stress fuels into knocking zone; data obtained can be analyzed to describe fuel antiknock or anti-preignition quality at infinite number of combinations; 14 practical applications and suggestions made.

### PRODUCTION

**Casting Processes in General, K. A. DIGNEY.** Presented Dec., 1956, 2 p. General description of casting processes common to some of ferrous and nonferrous materials and their alloys.

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These digests are provided by Engineering Index, which abstracts and classifies material from SAE and 1200 other technical magazines, society transactions, government bulletins, research reports, and the like, throughout the world.

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**ALSO AVAILABLE . . .**

. . . **1956 SAE TRACTOR PRODUCTION FORUM,** presented September 10–11. Secretaries' report of 8 panels on "Cost Reduction Programs," "Management Controls," "Tools, Dies, Jigs, and Fixtures," "Heat Treatment Techniques," "Automation," "Perishable Tools," "Communications in Plant Operation," and "Quality Control." Available as SP-316 from SAE Special Publications, 485 Lexington Ave., New York 17, N.Y. Price: $1.50 to members; $3.00 to nonmembers.

. . . **1956 SAE AIRCRAFT PRODUCTION FORUM,** presented October 2–3. Secretaries' report of 14 panels on "High Temperature Sandwich Construction," "Control of Manufacturing Costs," "Extrusions—Aluminum, Steel and Titanium," "Electronics—Testing and Checkout," "Quality and Process Control," "Fasteners — Conventional and Special," "Planning for Reduced Lead Time," Transparent Materials—High Speed Applications," "Manufacturing Techniques—High Temperature Sheet Materials," "Future Procurement and Subcontracting Problems," "Organizing for the Development of Manufacturing and Processing Techniques," "Machining — Numerically Controlled," "Future Technical Requirements," and "Forgings—Steel and Titanium." Available as SP-317 from SAE Special Publications, 485 Lexington Ave., New York 17, N.Y. Price: $2.00 to members; $4.00 to nonmembers.

## New Members Qualified

These applicants qualified for admission to the Society between April 10, 1957 and May 10, 1957. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

**Alberta Group**

Robert Moar (J).

**Atlanta Section**

Norman Dee Burns (M).

**Baltimore Section**

Robert S. Dowdy (A).

**British Columbia Section**

Alan Nisbet (A), C. G. A. Roach (A).

**Buffalo Section**

Reeve MacArthur Brown, Jr. (J), William D. Huston (M), Gilbert W. Langswager (J), William H. Tite, Jr. (J).

**Canadian Section**

Vincent Battaglia (A), Peter Gardner Browne (A), Elmer Edward Downs (A), Matthew Gasparovich (A), Frank R. Gerry (M).

**Central Illinois Section**

Norman Edward BeDell (M), Roy D. Chandler (M), Paul F. Dirksen (M), William B. Doyle (J), Gordon W. Johnson (J), Edwin J. Kirk (J), Ralph Lee Sisler (J), Roger Allen Stapf (J), Howard E. Ward (A), Richard B. Warren (J), Norman C. Zeter (J).

**Chicago Section**

George M. Bassnett (M), Bruno Biava (A), Charles Lewis Brand (J), Michael A. Chaszeyka (M), Allan E. Fitzpatrick (A), Daniel Gawne (A), William A. Hodges (A), Edward R. Hodgman, Jr. (M), Lee L. Lemke (M), Theodore L. Marks, Jr. (J), Richard B. Naylor (A), Robert A. Nejdl (J), Norman G. Olsen (M), Richard B. Payne (M), Otis S. Romine (A), Francis W. Smiley (M), Peter James Sorensen (J), G. Townsend Underhill (A), Theodore O. Wagner (M).

**Cincinnati Section**

Ray F. Bonhaus (A), Claude G. Franklin (A), N. F. Frischhertz (M), Jack M. Mitchell (A), James Thomas Volle (A).

**Cleveland Section**

Lester Garrett Beltz (A), William Arthur Campbell (M), Warren G. Hampton (M), Lars U. Hedlund (J), Edward H. Knabenshue (A), Gordon Meldrum (M), Richard S. Neely (M), Richard P. Reichold (J), Cecil William Roe (A), William J. Smith, Jr. (M).

**Dayton Section**

Richard Arthur Roberts, Sr. (A).

**Detroit Section**

Stanley S. Baibak (M), Nevin L. Bean (M), John S. Besemer (M), Robert C. Bichan (A), John Louis Bigus (J), W. Kenneth Bodger (M), M. Victor Bower (M), John N. Bradley (M), W. Durand Brown (M), Frank Malcolm Burhans (M), John Cory (M), Dale D. Douglass (M), Thomas M. Dukes (A), Henry N. Fedorchuk (J), Frank E. Field (M), Russel D. Foley (M), Ravender Nath Gheyee (J), Irving Vernon Gosnell (M), Frank B. Graper (A), Lynn W. Grover (M), Roger W. Holden (M), Donald H. Iacovoni (J), Carl J. Jackson (M), Peter R. Juk (M), Kenneth F. Koegler (M), Gunnar J. Kristola (M), James D. Mallory (M), John J. McAllister (M), Ivan N. Momtchiloff (J), Ernest G. Murray (M), Willard L. Pearce (A), Charles A. Pfister (A), Donald R. Pringle (M), William G. Richardson (A), William H. Ripking (A), Neil M. Romeo (M), Michael

## New Members Qualified

Continued

Rometti (M), Daniel W. Roper (M), John W. Rosenkrands (M), Ohannes Samuelian (J), Morton Edward Sewell (A), George R. Shilko (J), Fred Warren Shoemaker (M), Edward Thomas Sills (J), Robert L. Smith (M), Donald I. Streck (J), Robert E. Valk (M), J. Kenneth Williams (A), Albert Haig Wilson (A), Frank W. Wilson (M), James W. Winship (M).

**Hawaii Section**

Ralph E. Fuller (A), Norman Gerner (A).

**Indiana Section**

Frank G. Breiner, Jr. (M), Keith W. Epply (M), Dean K. Hanink (M), Francis J. Lasker (J).

**Kansas City Section**

Bill J. Bean (M), David B. Osborn (M), John N. Schlotter (M), John M. Smidl (M).

**Metropolitan Section**

Edward L. Apgar (M), Joseph Beyers, Jr. (M), William Thomas Bonomo (A), Robert E. Cohen (J), Frederick A. Fielder (A), Philip H. Fryberger (M), John A. Grimes (M), Frederick R. Gruner (M), Thomas W. Hall, II (J), David N. Harrison (M), Sidney C. Howell (M), W. Herbert Hultgren (M), John S. Kopper (A), Arthur S. MacDonald (J), Ward W. Minkler (M), Donald A. Webster (J).

**Mid-Continent Section**

Robert C. Curry (M), Jack W. Foster, Jr. (M), Leland Hoppe (A).

**Mid-Michigan Section**

Walter Vern Alley, Jr. (M), Frank Hayes, Jr. (M), Alfred E. Hilgeman (M), William G. Martin, Jr. (M), Gerald W. McArthur (J), Leonard F. Stewart (J), Keith T. Wolfenden (M).

**Milwaukee Section**

Kenneth A. Alexander (M), John D. Behnke (A), Clyde R. Bodenbach (A), Harris Ewald (M), Robert R. LeChevalier (J), Charles W. Modersohn (M), Roger W. Page (M), Richard M. Riesel (M), Bernard M. Silverberg (M), Robert E. Talley (M), S. E. Wolkenheim (A).

**Mohawk-Hudson Section**

C. Arthur Leland (A).

Continued on page 152

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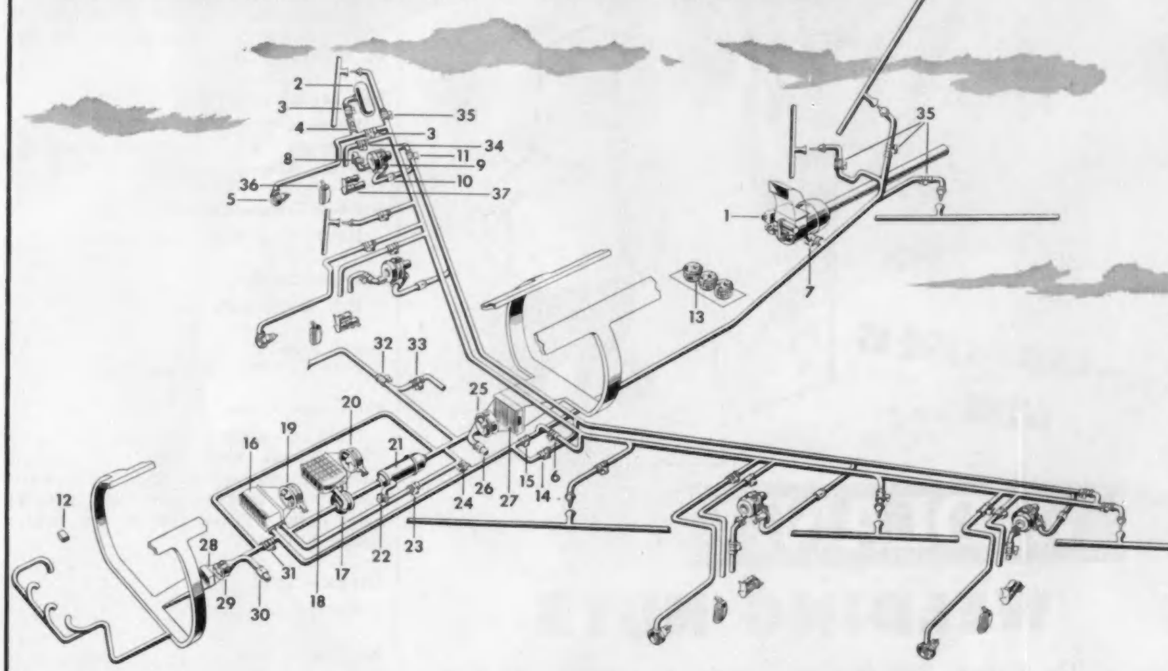

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2. Starter Air Bottle
3. Starter Shut-off and Control Valve
4. Line Combustor
5. Turbo Starter
6. Empennage Anti-icing or GTC Starting Shut-off Valve
7. Load Control Valve

**PRESSURIZATION**

8. Turbo Compressor Shut-off Valve
9. Turbo Compressor
10. Turbo Compressor Check Valve
11. Emergency Pressurization Valve
12. Cabin Pressure Controller
13. Cabin Outflow Valves

**AIR CONDITIONING**

14. Cabin Air Conditioning and Pressurization Shut-off Valve
15. GTC Air Conditioning Shut-off Valve
16. Primary Heat Exchanger
17. Bootstrap Refrigeration Unit
18. Secondary Heat Exchanger
19. Primary Heat Exchanger Cooling Air Fan
20. Secondary Heat Exchanger Cooling Air Fan
21. Water Separator
22. Water Separator Anti-icing Control Valve
23. Turbine By-pass Valve
24. Cabin Hot By-pass Valve
25. Cabin Recirculating Fan
26. Cabin Recirculating Fan Check Valve
27. Cabin Electric Heater
28. Flight Station Electric Heater
29. Flight Station Recirculating Fan
30. Flight Station Recirculating Fan Check Valve
31. Flight Station Hot By-pass Valve
32. Auxiliary Ventilation Control Valve
33. Ground Conditioning Valve

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## New Members Qualified

Continued

**Montreal Section**

Rolland Asselin (M), Stanley T. Ferry (A), John Frederick Gellard (A), R. N. Smith (M).

**New England Section**

Bernard B. Becker (M), Richard C. Fitzgerald (A), Clarence S. Goodwin, Sr. (A), Albert B. Liptak, Jr. (M).

**Northern California Section**

Henry F. J. Wilmot (M).

**Northwest Section**

Roy A. Gregory (A).

**Oregon Section**

Pete T. King (A), Gus Pautsch (A).

**Philadelphia Section**

John H. Geyer (M), Eugene Gore (M), Stuart Alan Horn (J), George Lewis Houghton (J), Charles H. Pancoast (J), Longly Lewis Sagendorph (A), James F. Stevenson (A), Raymond J. Tushar (J).

**Salt Lake Group**

Harold Jacobs (A).

**San Diego Section**

James R. Davidson (M), Robert E. Morris (M), Bernard J. Simons (M).

**South Texas Group**

Roy D. Quillian, Jr. (M).

**Southern California Section**

Irving Altman (M), Richard Battle (M), William Carroll (A), Joe C. Crowley, Jr. (M), Vernon Cunningham (M), Eric Arthur Davies (A), Arthur Tipton Doyel, Jr. (J), M. C. Haddon (M), Louis Stanley McBride (J), Palmer Nicholls (M), John McCormick Phipps (M), William A. Ray (M), W. Earl Smith (A), Harry J. Swartz (M), Otto Charles Turchan (M).

**Southern New England Section**

W. Ernest Bancroft (M), Earl M. Curtis (M), Joseph L. Magri (M).

**Syracuse Section**

Richard N. Audas (A), Joseph A. Calleo (M).

**Texas Section**

Roy H. Coleman (M), William R. Massey (J), Ray McKinley Matson (M).

**Texas Gulf Coast Section**

A. S. Gardenshire (M).

Continued on page 155

## New Members Qualified

Continued

**Twin City Section**

Lyle M. Jensen (A).

**Washington Section**

Edgar Hamilton Fallin (A).

**Western Michigan Section**

Frank Dzielski (M).

**Williamsport Group**

Warren R. Horak (J).

**Outside Section Territory**

Norris E. Bacon (M), Paul E. Carlson (M), Robert D. Dixon (J), John L. French (M), Henry W. Hanley (M), Charles W. Martin (J), Horst Martin Schweighofer (M), Lee R. Scott, Jr. (M), Harold K. Smith (A), Lt. Robert Moyer Smith (J), Wendell M. Van Syoc (M), George Richard Verhage (M), Walter Vogel (J).

**Foreign**

Richard K. Hall (M), Venezuela; Lennox S. Honeyborne (A), South Africa; Yutaka Katayama (M), Japan; Vincent Allison Morris (M), South Africa; Carl Alexander Olsson (M), Sweden.

## Applications Received

The applications for membership received between April 10, 1957 and May May 10, 1957, are listed below.

**Baltimore Section**

George M. Bunker, Albert W. Foreman

**British Columbia Section**

Harold F. M. Robinson, Ernest Scott

**Buffalo Section**

Robert B. Clapper, Vaughn H. Hardy, John Gerard Hart, John E. Kinsky, John Noble MacKendrick, Ivan W. Miller, Frank M. O'Neal.

**Canadian Section**

C. P. Farr, William B. Flora, William Henry, O. John Krohn, Frederick O. Popham.

Continued on page 157

## Applications Received

Continued

**Central Illinois Section**

Hubert D. Boggs, Charles F. Boren, Alexander P. Brouwers, Albert W. Crumrine, Robert W. Gendron, Milan Boyd Hendricksen, Richard Allen Hickman, Wesley C. Leveck, Loren N. Petersen, Patrick J. Sweeney, Thornton L. Vrell, J. Arthur Weber, Lowell J. Wuthrich

**Chicago Section**

George D. Aravosis, David Blair Digel, Frank M. Guinn, William T. Harrison, Alexander Kapocius, Thaddeus J. Lopatka, Ronald Vincent Miskell, Robert W. Olsen, Merle W. Paquette, Harry Daniel Robb, James G. Tulley, Michael M. Woelfel

**Cincinnati Section**

John W. Bergman, Emil L. Eckstein, Morris R. Lynn, John B. Montgomery, Jerome Rich

**Cleveland Section**

Charles Rose, Richard C. Bryan, Forrest, L. DuRant, Jr., Robert E. Forrester, David M. Gaskill, Orris H. Johnson, James Carl Keebler, Frank A. Kender, W. F. Klein, M. H. MacKusick, Norman J. Musil, Fred B. Schneider, Clark I. "Bud" Witmer

**Colorado Group**

Donald E. Yadon

**Dayton Section**

Maurice S. Decker, Jr., Ernest Ray Rutherford, Richard G. Schumann, Robert E. Teeghman

**Detroit Section**

Robert Sumner Anderson, George E. Bandli, Veli Hulusi Basat, John C. Basiletti, Donald Peter Boarder, Fred Brown, Earl F. Burton, William R. Callow, A. J. Carter, John W. Compton, Charles E. Dell, Richard J. Dunklau, Dudley F. Fiscus, F. D. Fountain, Robert K. Frank, Samuel Frank, George F. Gerbstadt, Paul A. Gionet, Eugene K. Groves, Dale A. Guoin, William B. Heaton, George F. Hodgson, Emil G. Holmberg, Everett P. Kennedy, Douglas Wigham Knowles, Paul John Lampela, Thomas E. Lootens, Floyd B. Lux, Robert J. O'Grody, Ian R. Olley, John F. Randall, Helen Holt Reeves, Robert L. Reid, Carl D. Rogers, Julian J. Schamus, Fred G. Seaver, Donald K. Smith, Richard E. Stover.

**Hawaii Section**

John A. Vidal

**Indiana Section**

John Saxon Ivey, Jules B. Maassen, Victor W. Peterson, Theodore A. Spanke, Frank B. Stewart

**Kansas City Section**

James R. MacPherson, Kenneth B. Tilbrook

**Metropolitan Section**

George V. Cambeis, Jr., J. Dillard Collins, Jacques M. Elsner, Ambrose J. Florio, Harold G. Haas, Herman M. Hanink, Robert H. Johnson, Eugene J. Keenoy, Jr., Erik Nelson, Howard E. O'Neill, Martin Solon, Herbert H. Vickers, Leo W. Weiss, William W. Wight

**Mid-Continent Section**

Robert A. Lauducci

**Mid-Michigan Section**

Richard E. Durkee, Donald L. Massy,

Continued on page 158

## Applications Received

Continued

Harold P. McAlindon, Duane H. McCormack

**Milwaukee Section**

John W. Armstrong, Wayne E. Hartman, Norbert F. Mullaney, Boyd S. Oberlink, Richard James Radwill, John S. Randall, Robert David Schouten

**Montreal Section**

Stephan Gyurik, E. Glen D. Maynard, William George Park Merrifield, John Gordon Earle Metcalf

**New England Section**

Allen Howard Bolinder, Francis L. Bry, Carl Dennis, Charles I. Foss, Joseph Witkum, Morris B. Wood

**Northern California Section**

Robert E. Dilling, John Harkins, Homer W. Harralson, Neal C. Jern, Don A. Swain

**Northwest Section**

Lionel R. Atkinson, Allen Russell Ohlinger

**Philadelphia Section**

Sidney H. Abrams, Philip I. Berman, Russell O. deCastongrene, Jr., David C. Fariss, Norman W. Fesmire, Herman Frederick Hoffmann, Alexander J. MacRae, John K. Titus

**Pittsburgh Section**

Wesley M. Rohrer, Jr.

**St. Louis Section**

Louis E. Astroth

**San Diego Section**

Pedro Jose Alberto Aperlo, John Dillon Fink, Romie A. Taylor

**Southern California Section**

Clifford D. Cannon, Robert F. Connelly, Courtland B. Frain, Ronald F. George, John Haggerty, Peter D. Lawcock, Leo Lofchie, Arthur Nielsen, Philip Nuccio, Gene Harold Pearson, Raymond H. Rice

**Southern New England Section**

Otto Paul Karp

**Syracuse Section**

F. A. Root

**Texas Section**

Alvin Hill, Bruce Forrest McCall, Richard Earl Witte

**Texas Gulf Coast Section**

Clinton Eugene Bennett, Eugene W. Buckles, J. Taylor Hood, Walter E. Liljestrand, Joe D. Little

**Twin City Section**

Harold Leigh Julian Aga, Olaf T. Aho

**Virginia Section**

Robert B. King

**Washington Section**

George R. Petty, Jr.

**Outside of Section Territory**

Thomas M. Adams, Clarence D. Fox, Victor F. Hunt, Warren J. Kopf, Ronald L. Krolak, John Y. McCollister, Adrian J. Moorhead, Waldo E. Rodler, Jr., Roy A. Shannon

**Foreign**

Sabahattin Algan, Turkey; Edward A. Driessen, Netherlands; Osama Amin El-Kholy, Egypt; Cyril Fountain, England; Cyril F. Holloway, England; N. Ramachandran Nair, India; Kotcherlakota Sri Rangasai, India; Graeme Reid, England; William Kelsey Walters, Venezuela

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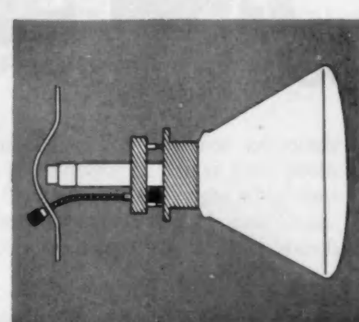

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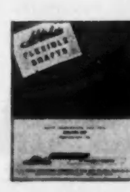

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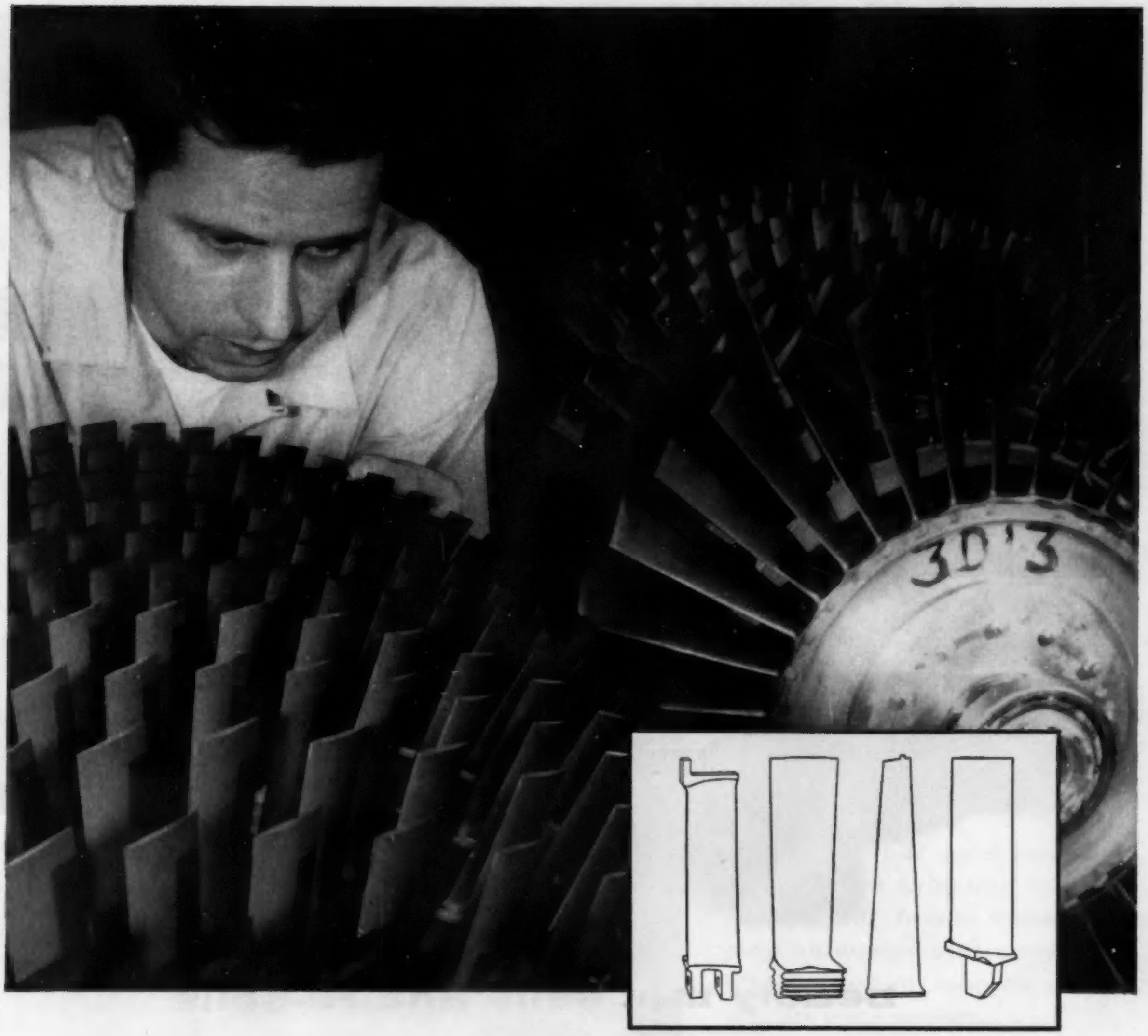


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# AUTOMOTIVE ENGINEERING NEWS

LATEST PROPERTY AND APPLICATION DATA ON

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## Parts of TEFLON® tetrafluoroethylene resins for power-steering unit reduce break-away effort, give smoother steering

No other single engineering material can match the combination of properties found in Du Pont tetrafluoroethylene resins. Their mechanical, electrical, thermal and chemical properties provide unique design possibilities.

The power-steering unit shown at right makes parking almost twice as easy—allows more relaxed driving in traffic and on long trips. Featured in this automotive advance are seals, piston ring and lock-nut seal ring made of TEFLON tetrafluoroethylene resins. Parts of TEFLON resins were chosen for these applications because of their low coefficient of friction and toughness. TEFLON resins have the lowest coefficient of friction of any solids in commercial use—a kinetic coefficient of 0.04 has been measured.

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TEFLON tetrafluoroethylene resins are inert to nearly all chemicals and solvents normally used in commercial practice. Exceptions to this include alkali metals under certain conditions. In addition at elevated temperatures and pressures, halogens and certain halogenated chemicals and solvents may affect them.

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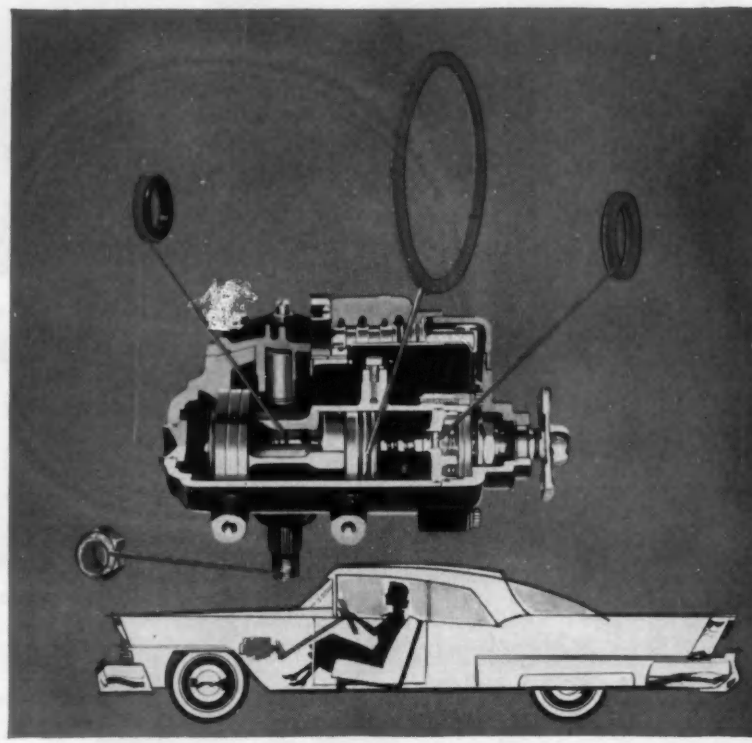

Parts made of TEFLON resins have substantially reduced break-away effort in the power-steering mechanism shown above. Seals of these resins, even when under high pressure, allow shaft to turn freely, solving binding problem caused by other materials.

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**Room 56, Du Pont Building, Wilmington 98, Delaware**

Please send me more information on Du Pont TEFLON tetrafluoroethylene resins. I am interested in evaluating these materials for________

*Name*________

*Company*________ *Position*________

*Street*________

*City*________ *State*________

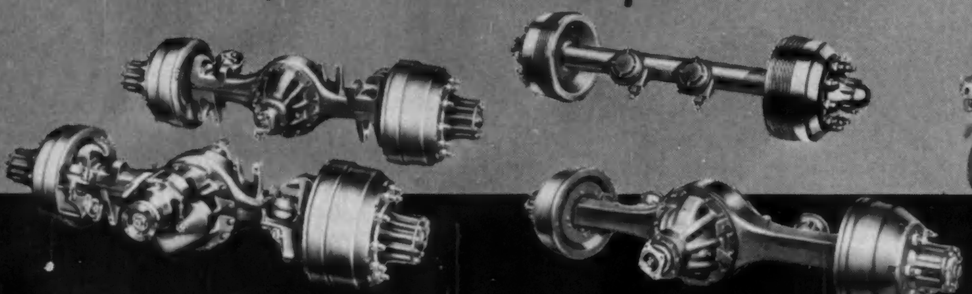
*Type of Business*________

In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box [illegible], Montreal, Quebec

SPECIFY...

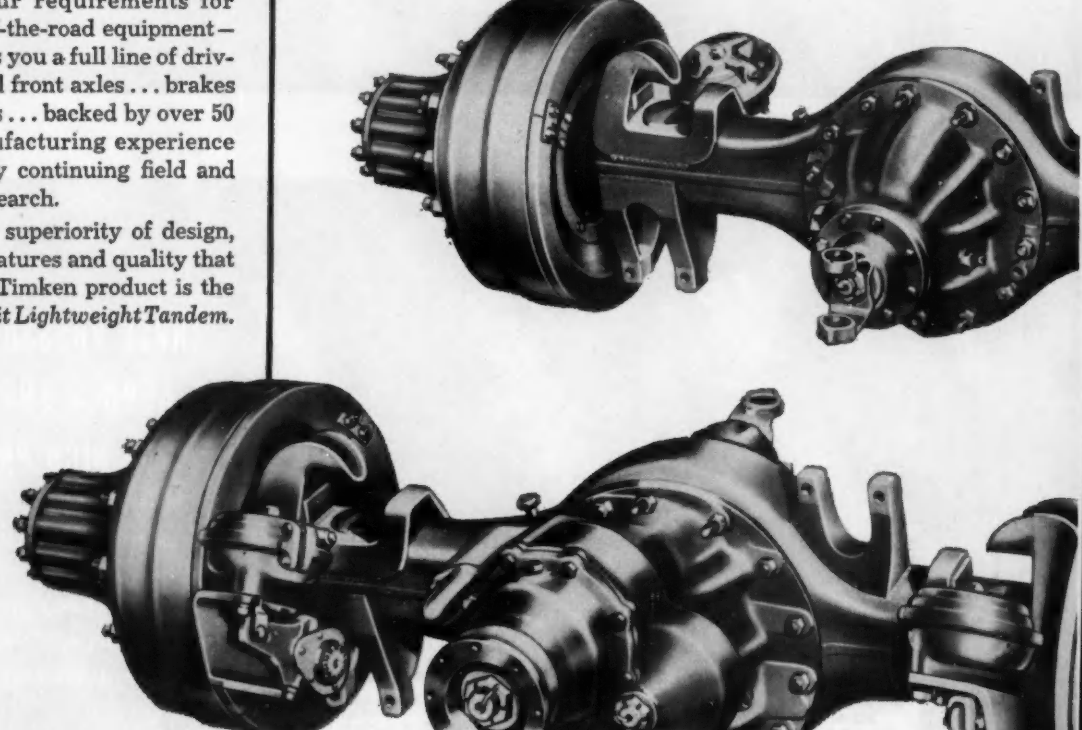
# TIMKEN-DETROIT®

## Today's Most Complete Line of Quality



Whatever your requirements for highway or off-the-road equipment—Timken® offers you a full line of driving, trailer and front axles . . . brakes and gear boxes . . . backed by over 50 years of manufacturing experience and proven by continuing field and laboratory research.

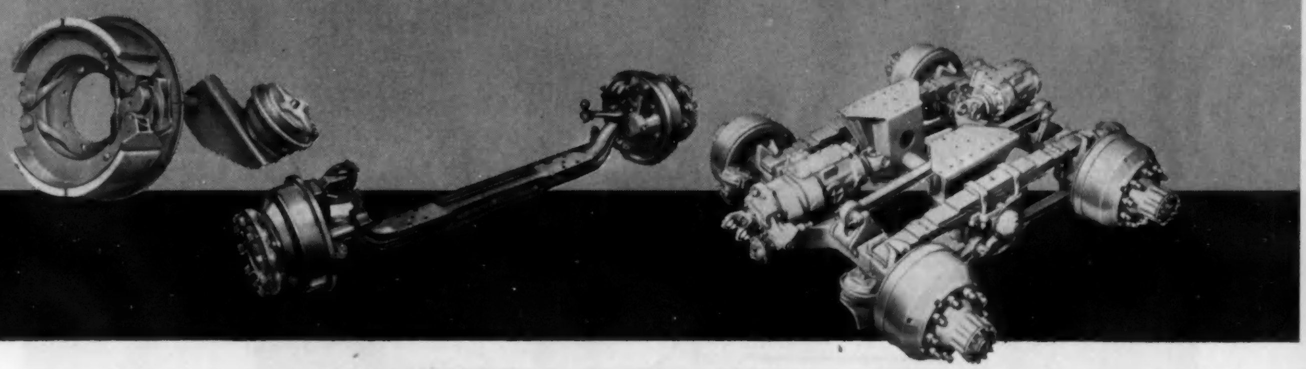
Proving the superiority of design, engineering features and quality that go into every Timken product is the *Timken-Detroit Lightweight Tandem.*



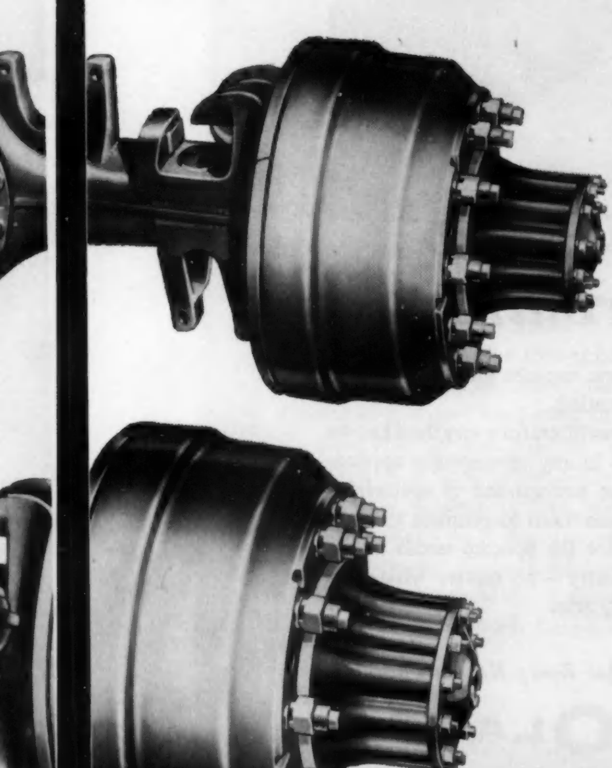
Products of

# Rockwell Spring and Axle Co.

## Axles and Brakes for Commercial Vehicles



## TDA® LIGHTWEIGHT TANDEM GIVES YOU...



**Greater Payload Capacity!** Up to 700 pounds lighter than any other unit of equal capacity, this new TDA tandem will give you up to 26,000 extra ton-miles payload in every 75,000 miles of operation.

**TDA Parts Interchangeability** means easier maintenance. Almost all the parts in this new tandem—gears, pinions, differentials and brakes—are interchangeable with parts from Timken-Detroit standard single axles. This assures you more productive road time . . . faster, simpler, more economical maintenance . . . and smaller parts inventory.

**TDA Inter-Axle Differential** divides torque evenly between axles . . . yet permits wheels of one axle to revolve faster or slower than wheels of the other axle. This means both axles are doing equal amounts of work... driving parts and tires last longer.

**Driver-Controlled Lockout!** With TDA Inter-Axle Differential, the driver can obtain the advantages of straight-through drive under slick or icy conditions by locking out the differential at any driving speed.

**Big, Dependable Hypoid Gears** rotate in correct direction for maximum gear and bearing life.

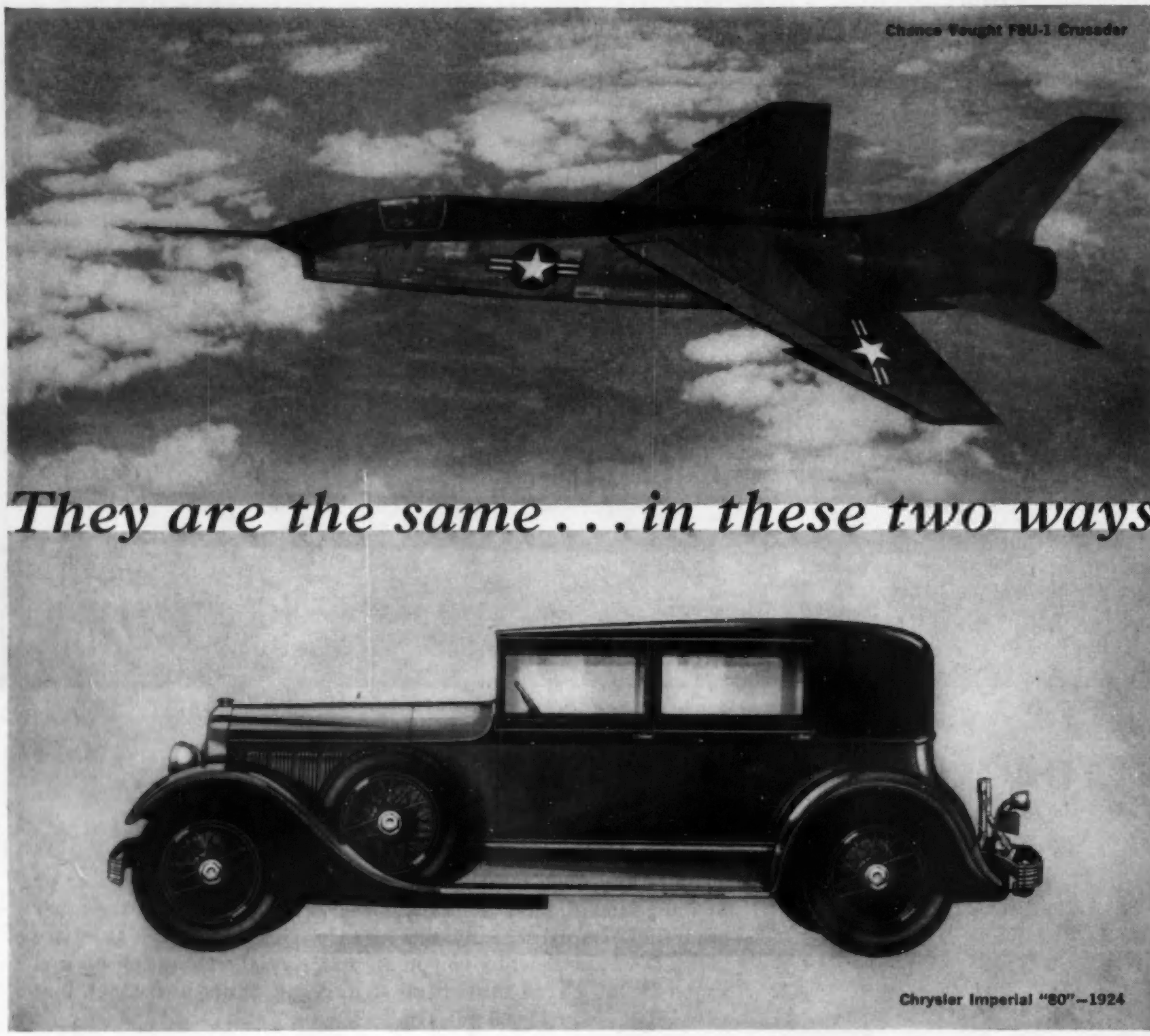
Plants at: Detroit, Michigan • Oshkosh, Wisconsin
Utica, New York • Ashtabula, Kenton and
Newark, Ohio • New Castle, Pennsylvania

**TIMKEN Detroit AXLES**

TIMKEN-DETROIT AXLE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
DETROIT 32, MICHIGAN

The Accepted TDA Standard
TRADE MARK REGISTERED

***WORLD'S LARGEST MANUFACTURER OF AXLES FOR TRUCKS, BUSSES AND TRAILERS***




# . . . engineering leadership and filtration by Purolator!

Thirty-four years ago, that Chrysler came off the assembly line equipped with something entirely new: an oil filter. By 1956 when the Chance Vought F8U-1 Crusader shattered the national speed record, filters were accepted as basic components on all automobiles and aircraft. Both events were milestones – both vehicles were protected by Purolator.

The 1924 Chrysler seems a relic of another age, while the Crusader is as new as tomorrow. But the concept that got its start with the Chrysler has become fundamental everywhere . . . any fluid – be it air, fuel, lube oil, hydraulic fluid or anything else–which is vital to the proper operation of any aircraft, automobile or machine, must be filtered to be kept free of contamination.

Purolator makes filters for every fluid known to man–for use in any conceivable application. The unique background of specialized know-how enables them to produce the best possible filters for the specific needs of the automotive industry – no matter what they are or when they arise.

*Filtration for Every Known Fluid*

**PUROLATOR**

**PRODUCTS, INC.**

Rahway, New Jersey and Toronto, Ontario, Canada

## *Industries served by* AUTO-LITE

**WITH OVER 400 PRODUCTS OF THE HIGHEST QUALITY**

**GOVERNMENT**

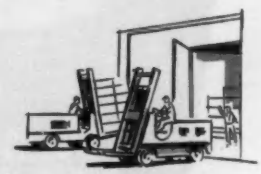
Spark plugs • Batteries
Electrical equipment • Special products
Wire and cable

**INDUSTRIAL ENGINES**

Electrical equipment • Spark plugs
Batteries • Wire • Instruments
Name plates • Die castings

**ELECTRONICS**

Wire • Die castings
Name plates • Molded plastics

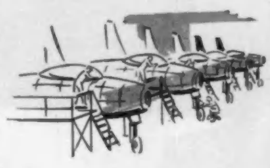


**MATERIAL HANDLING**

Electrical equipment • Traction motors
Lift motors • Wire and cable
Dashboard instruments
Spark plugs • Batteries • Horns
Name plates • Molded plastics

**AUTOMOTIVE REPLACEMENT**

Service Parts for
Auto-Lite-equipped vehicles
Spark plugs • Batteries • Wire and cable



**AVIATION**

Wire and cable • Instruments
Batteries • Spark plugs
Name plates • Die castings

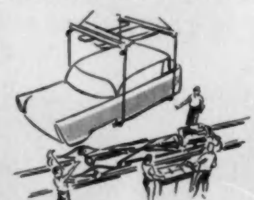
**ELECTRICAL APPLIANCES**

Wire • Die castings • Name plates
Molded plastics • Instruments

**FARM EQUIPMENT**

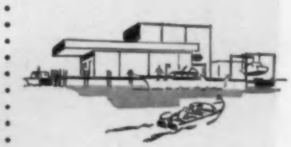
Electrical equipment
Batteries • Spark plugs
Wire and cable • Instruments
Name plates • Molded plastics

From twenty-nine plants in twenty-three communities throughout the United States and Canada, Auto-Lite serves industry with more than 400 products of the highest quality. Whether it be intricate die castings, wire for modern aircraft, electrical equipment for the automotive industry, or any one of hundreds of other products . . . it serves best when it comes from Auto-Lite.



**AUTOMOBILES AND TRUCKS**

Automotive electrical equipment
Bumpers and grilles • Wire and cable
Dashboard instruments
Die castings • Molded plastics
Tail-light assemblies • Spark plugs
Batteries • Windshield wipers
Horns • Seat and window actuators
Hub caps • Toplift motors
Scuff plates • Iron castings
Name plates



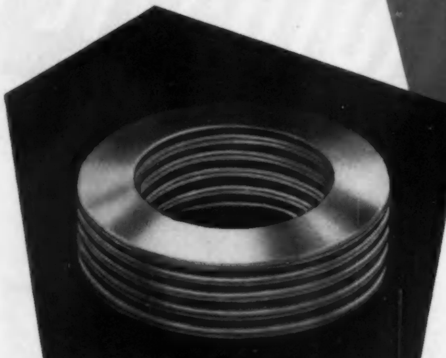
**MARINE**

Electrical equipment for inboard motors
Electrical starting motors
and equipment for outboard motors
Batteries • Wire and cable
Spark plugs • Horns • Name plates
Molded plastics • Die castings

**THE ELECTRIC**
**AUTO-LITE COMPANY**
**TOLEDO 1, OHIO**

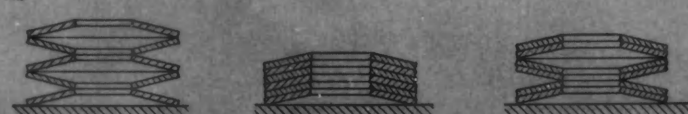
# Belleville Springs

## Solve Spring Problems of HIGH LOADS in a Limited Space

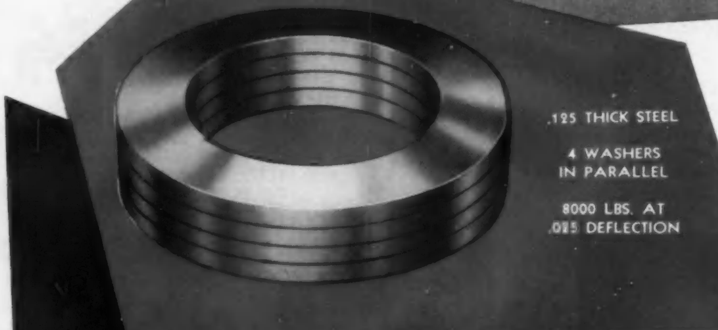


.025 THICK STEEL
10 WASHERS IN SERIES
35 LBS. AT .250 DEFLECTION

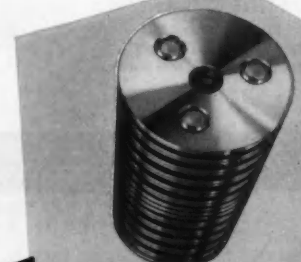
This useful type of spring may be the answer to your need where space and load requirements are a problem. Made to any diameter or thickness—can be stacked in series, parallel, or parallel-series, or as an "Energy* Cartridge." The experience of our engineers is available in a pamphlet, "Belleville Washers." Write for your copy.



IN SERIES — IN PARALLEL — IN PARALLEL-SERIES



.125 THICK STEEL
4 WASHERS IN PARALLEL
8000 LBS. AT .025 DEFLECTION



ENERGY* CARTRIDGE
*Patented

WALLACE BARNES COMPANY, BRISTOL, CONNECTICUT

THE WILLIAM D. GIBSON COMPANY, 1800 CLYBOURN AVE. CHICAGO 14,

RAYMOND Manufacturing COMPANY, CORRY, PENNSYLVANIA

BARNES-GIBSON-RAYMOND, 40300 PLYMOUTH RD. PLYMOUTH, MICH.

B-G-R COOK PLANT, ANN ARBOR MICHIGAN

DIVISIONS OF ASSOCIATED SPRING CORPORATION — COAST TO COAST

SEABOARD Pacific Div., 15001 S. BROADWAY GARDENA, CALIF.

OHIO DIVISION, 1825 EAST FIRST ST. DAYTON, OHIO

WALLACE BARNES COMPANY, STATE FAIR BLVD. SYRACUSE 9 (Solvay), N.Y.

MILWAUKEE DIVISION, 341 E. ERIE ST. MILWAUKEE, WIS.

DUNBAR BROTHERS COMPANY, BRISTOL, CONN.

F. H. MANROSS AND SONS CO., BRISTOL CONNECTICUT

THE WALLACE BARNES CO., LTD., HAMILTON CANADA

5710
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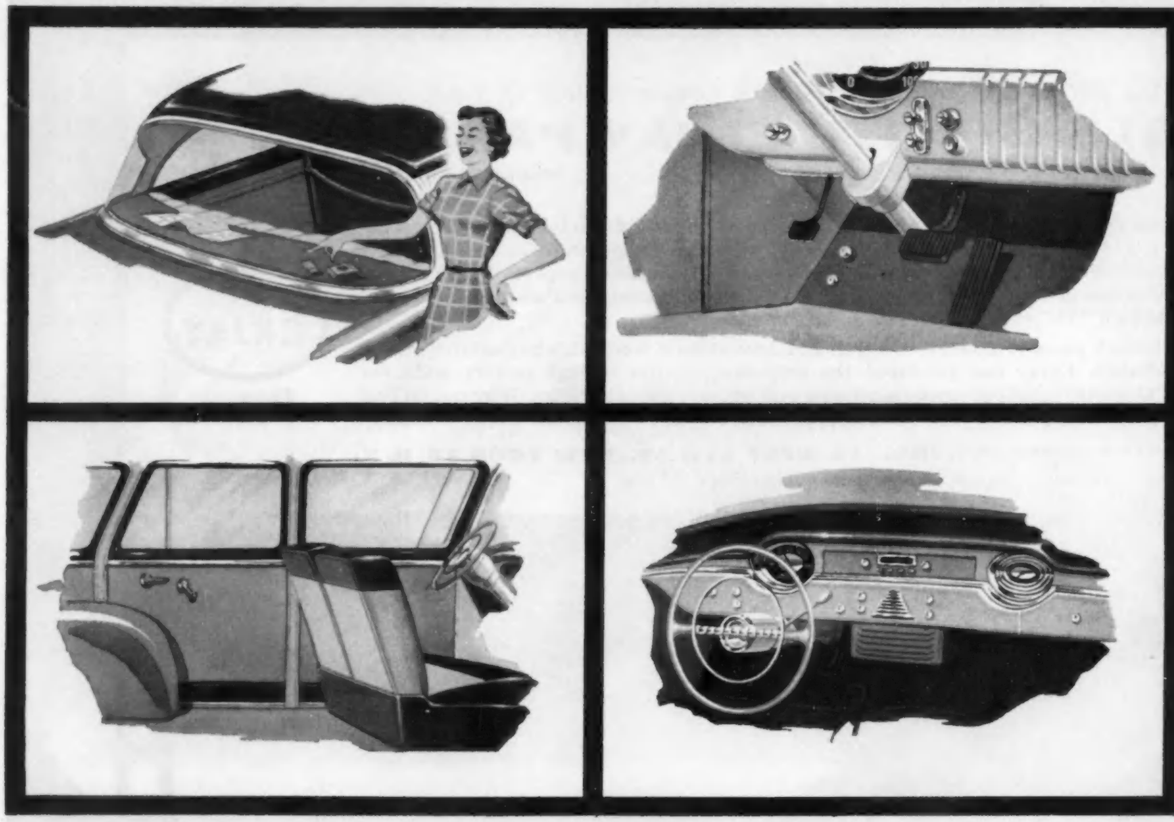
*Divisions of*

**ASSOCIATED SPRING CORPORATION**

GENERAL OFFICES: BRISTOL, CONNECTICUT

# Naugatuck Marvibond



**vinyl-to-metal... laminated before forming**

MARVIBOND† is Naugatuck's patented laminating process that permanently bonds MARVINOL® vinyls to practically any sheet-metal *before the product is formed.* Bonded in flat sheets or coils on a continuous production basis, Marvibonded laminates can be bent, crimped, drilled, punched, or deep-drawn without fracturing the finish—without weakening the adhesive. And they're available in practically any surface effect!

Chemical, abrasion and weather resistant, Marvibonded metals provide your product with a finish far superior to paints, lacquers, varnishes, phenolic and alkyd finishes, as well as upholstered ones. Scuff-marks, fingerprints and stains wipe off with a damp cloth.

This exceptional material can be used economically everywhere that sheet metal is used... dashboards, window trim, door panels, kick panels, truck cabs and other interior automotive components. For technical data, samples and the names of licensed laminators in your area write to us on your company letterhead.

†U. S. Pat. No. 2,728,703

**United States Rubber**

**Naugatuck Chemical Division**

**Naugatuck, Connecticut**

BRANCHES: Akron • Boston • Gastonia, N. C. • Chicago • Los Angeles • Memphis • New York • Phila.
IN CANADA: Naugatuck Chemicals, Elmira, Ontario • Rubber Chemicals • Synthetic Rubber • Plastics • Agricultural Chemicals • Reclaimed Rubber • Latices • Cable Address: Rubexport, N. Y.

*MORE AND MORE*

# MAJOR COMPONENTS

*ARE BUILT BY ROHR*

For example, brazed, stainless steel, honeycomb panel structures are being manufactured by Rohr for the great new B-58 Hustler, built by Convair for the U. S. Air Force.

Today Rohr manufactures over 30,000 airplane parts, included in such major components as stabilizers, elevators, fuselage sections, pneumatic system components, high strength weldments, and stainless steel honeycomb sandwich panels.

More and more, leading air-frame manufacturers count on Rohr for design engineering, for conception, development and production of parts to meet modern flight problems. In many cases, Rohr engineering teams are actually assigned to the customer's plant, to work with the manufacturer's engineering staff and bring back a full understanding of requirements to be met.

And, of course, Rohr is well known as the world leader in production of ready-to-install power packages for airplanes – including the Boeing B-52, KC-135, 707, Convair 880, Lockheed Electra Propjet, Super Constellation, C-130, Douglas DC-7 – and many other of America's leading military and commercial planes.

For the aircraft parts you need, next time look to Rohr.

**WORLD'S LARGEST PRODUCER OF READY-TO-INSTALL POWER PACKAGES FOR AIRPLANES**

**ROHR**
AIRCRAFT CORPORATION

**Excellent career openings now for engineers and tooling technicians.**

**CHULA VISTA, CALIFORNIA**

**Also plants in Riverside, California • Winder, Georgia • Auburn, Washington**

# How Great Lakes Steel *inspects scrap* quality

Two things don't belong in this gondola—and a team of trained Great Lakes Steel scrap inspectors is searching them out. The intruders are *non-ferrous material* and *high sulphur content ferrous material*, which contaminate heats and spoil the quality of finished steel.

Additional visual inspection in the stockhouse and on the open-hearth floor, magnetic screening, and weight checks all combine to detect and eliminate these adulterants, before the scrap is fit to become a part of Great Lakes steel.

Sound like a lot of trouble? It's worth it, to us and to our customers. And it's just one more step in Great Lakes Steel's continuing program of quality control that assures you the finest steels. Make it a point to contact your Great Lakes Steel representative for the rest of the story. He's as close as your telephone.

*Here approved scrap, in charging boxes on buggies, heads for the open hearths. Quality scrap gives finished steel improved surface and ductility characteristics.*

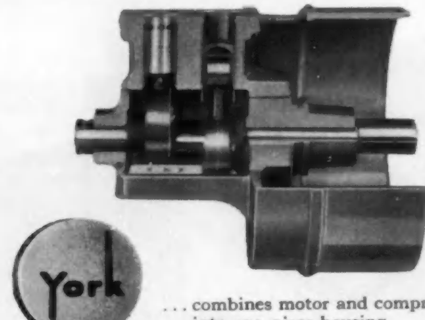
**GREAT LAKES STEEL CORPORATION**

**Detroit 29, Michigan • Division of**

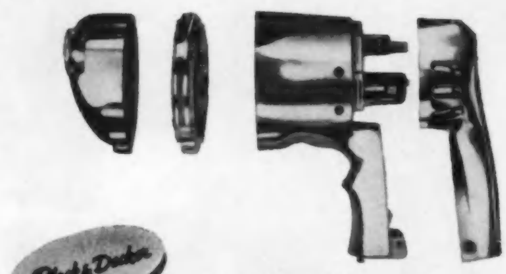
**NATIONAL STEEL CORPORATION**

*District Sales Offices:* Boston, Chicago, Cincinnati, Cleveland, Grand Rapids, Houston, Indianapolis, Lansing, Los Angeles, New York City, Philadelphia, Pittsburgh, Rochester, St. Louis, San Francisco, Toledo, Toronto.

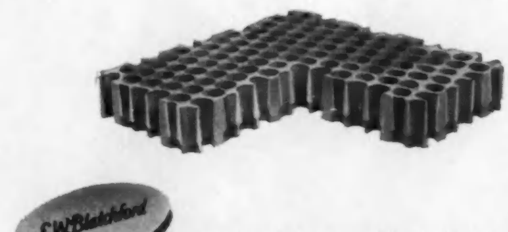
. . . makes camera parts *light-tight* and *interchangeable*



. . . combines motor and compressor into *one-piece* housing



. . . cuts finishing of power tools to *one buffing* operation



. . . makes "Honeycomb" printing base in *only way* it could be done

. . . concentrates *weight where needed* in floor waxer

. . . closely *matches section thicknesses* to strength requirements of appliances

# A dozen blue-chip products Doehler-Jarvis die-

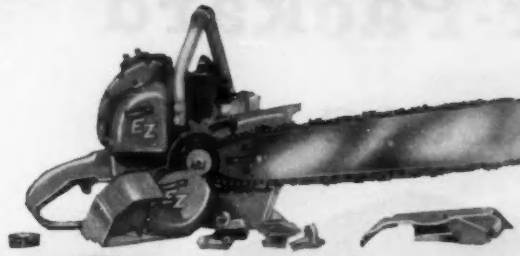
Each of these twelve products is outstanding in design.

One is extra light. Another is unique for precision. A third is remarkable for space economy. Each has a key feature that helps make it a success.

All these patterns of success are variations on a single theme . . . the skillful use of Doehler-Jarvis die castings to achieve design objectives.

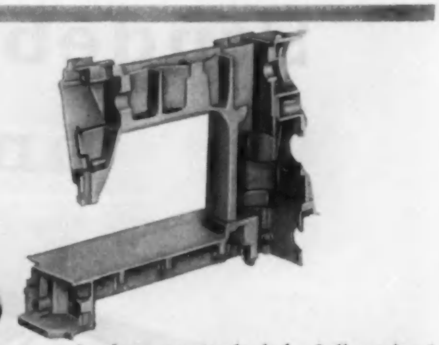
In each case, the manufacturer brought Doehler-Jarvis into the design picture at an early stage. Customer and D-J engineers worked out the specifics . . . the basic contours, the section, the coring, the ribbing, the ejection lugs, machining base points, finish . . . all the fine points.

Design results have been enviable. And frequently there have been important side benefits . . . metal saved, machining and assembly operations by-passed, finishing steps reduced, rejects prevented.



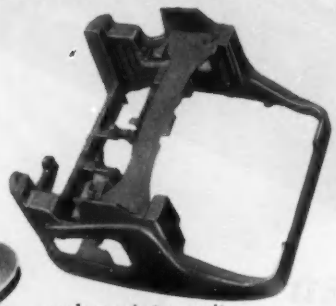
HOMELITE

... packs 5 horsepower into chain saw weighing *only 19 pounds*



SINGER

... develops new standards for *3-dimensional* precision in sewing machine assemblies



Underwood

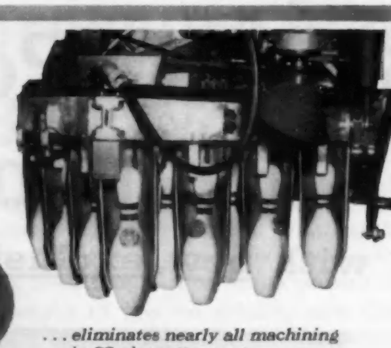
... replaces *six* typewriter frame castings with *one*

Western Electric

... makes *one* unit of space do the work of *six* in telephone terminal equipment

Sears Roebuck

... designs mower housing for *built-in assembly savings*



AmF

... *eliminates nearly all machining* in 99 pinspotter parts

# illustrate a dozen ways castings improve product design

**Take your cue from the makers of these successful products**

If you're looking for ways to improve your product, lower its cost, or speed its production ... or if you're developing new devices ... do what the makers of the products shown above did. Call in Doehler-Jarvis.

We'll be glad to help you evaluate the possibilities for you in die castings.

**Doehler-Jarvis**

DIVISION OF NATIONAL LEAD COMPANY

General Offices: Toledo 1, Ohio

In Canada:

Barber Die Casting Co. Limited

Hamilton, Ontario

TRADE MARK

# Studebaker-Packard announces


# Sealed Power KromeX Piston Ring Sets

## with new, exclusive Stainless Steel Oil Ring

To augment the selection of the finest parts and accessories for all dealers, Studebaker-Packard in cooperation with Sealed Power engineers now adds a line of KromeX Piston Rings especially designed for replacement service in Studebaker and Packard Engines.

TESTED AND STUDEBAKER PACKARD APPROVED

S-P SUPERIOR PERFORMANCE Guaranteed

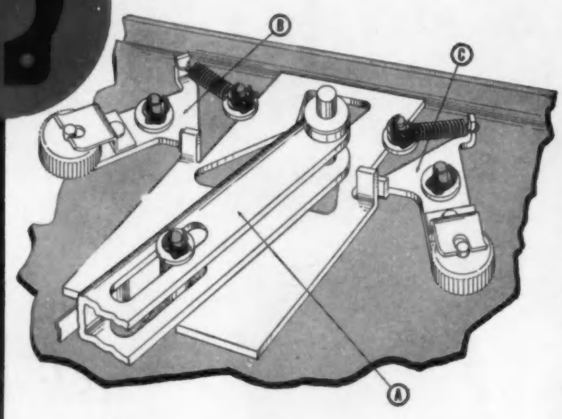
PRECISION BUILT PRODUCTS

**Parts and Accessories Division**

STUDEBAKER-PACKARD CORPORATION

# Waldes Truarc grip rings used on die-cast studs eliminate threading, tapping, other costly machining

**Mark Simpson Manufacturing Co.,** Long Island City, N. Y., uses Waldes Truarc series 5555 Grip Rings to secure parts to studs of the zinc die-cast base of its "Masco 500" portable tape recorder.
The rings—which need no grooves—replace nuts, screws, cotter pins and other types of fastening devices which require threading, tapping, drilling and other expensive machining operations. Because a single cracked or broken stud would render the entire cast base useless—and with it, all assembly completed to that point—the rings also eliminate extremely costly rejects.



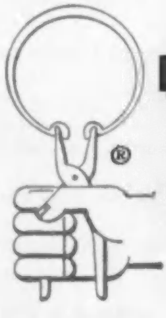

**Pivot Assembly** of shift lever (A) is secured by a single Waldes Truarc Grip Ring and washer. Because the washer must be installed over the shift level in a sliding fit, critical tolerances would have to be maintained if a screw or cotter pin were used. The Truarc Grip Ring eliminates that problem: it requires no groove and may be seated over the washer at any point on the stud, automatically compensating for accumulated tolerances in the parts. BRAKE ASSEMBLIES (B and C) use Grip Rings to secure the brake wheel and spring subassemblies. Here again problems of critical tolerances are avoided and expensive rejects eliminated.

**Whatever you make,** there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

**36 functionally different types**... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

**More than 30** engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

**For precision internal grooving and undercutting... Waldes Truarc Grooving Tool!**



**WALDES**
**TRUARC®**
**RETAINING RINGS**
**WALDES KOHINOOR, INC.**
**47-16 AUSTEL PLACE, L. I. C. 1, N. Y.**

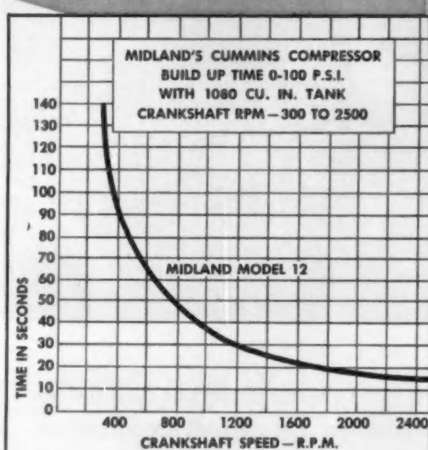
**Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N.Y.**
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
*(Please print)*
*Name*..........
*Title*..........
*Company*..........
*Business Address*..........
*City*.......... *Zone*..... *State*..........
SA069

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

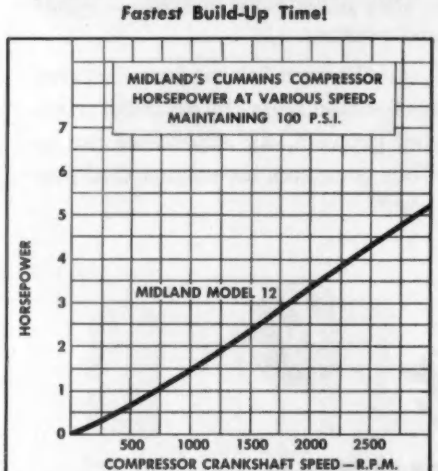
**MIDLAND**

# Money-Saving Model 12 Compressor Now Available For CUMMINS Engines!

The Midland governor is small, compact, efficient, can be mounted either on the compressor or remotely.




**Midland Model 12 Compressor Has *Fastest* Build-Up Time!**




**Midland Model 12 Compressor Requires *Least* Horse Power!**

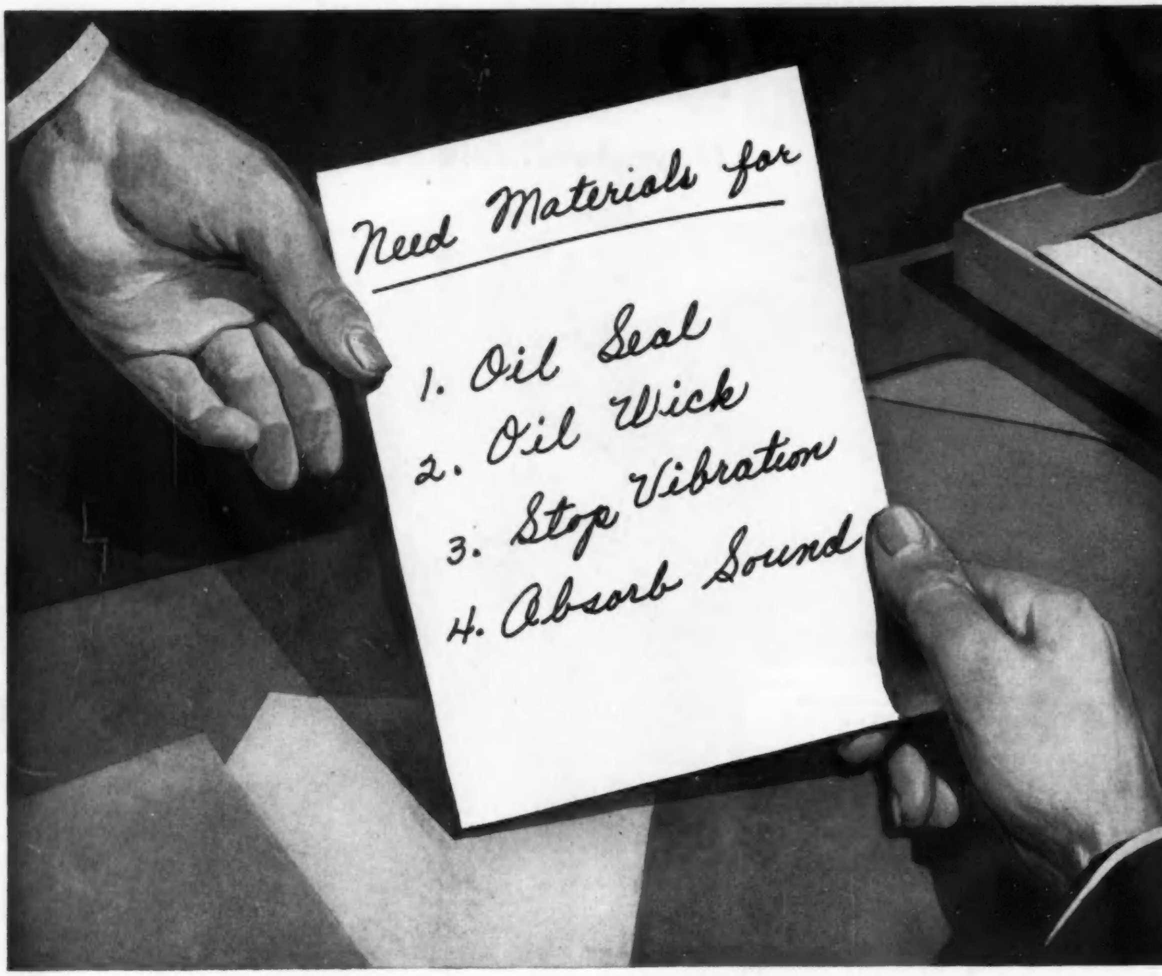
**ALL THE ADVANTAGES** of the Model 12 Midland Compressor can now be enjoyed by truck operators using Cummins engines.

This latest addition to the famous Midland line of compressors is expertly designed and quality built throughout. Amazingly light (up to 1/3 less weight), it requires less horsepower per cubic foot of air, protects against oil passing, runs cooler.

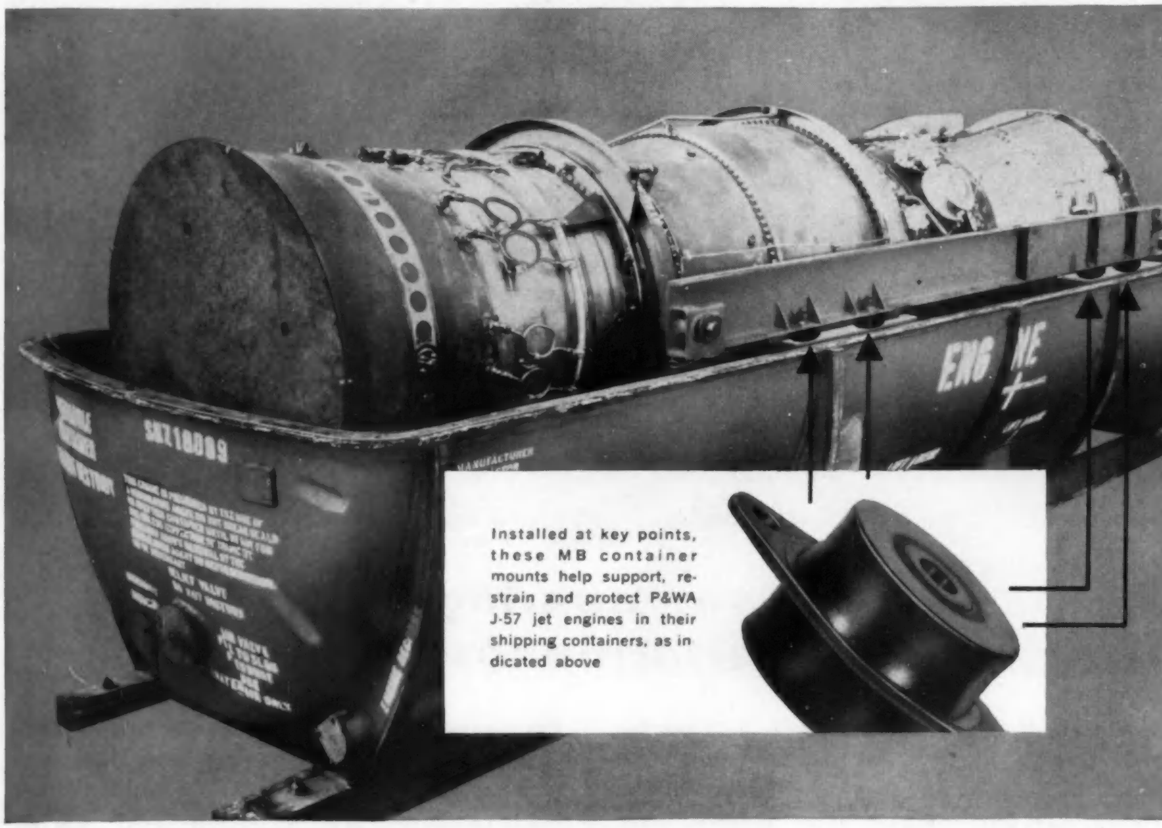
Your nearest Midland Distributor will gladly furnish you with complete information on this new compressor engineered especially for top efficiency and savings with Cummins engines.

**THE MIDLAND STEEL PRODUCTS COMPANY**
OWOSSO DIVISION • OWOSSO, MICHIGAN
*Export Department 38 Pearl Street, New York, N. Y.*

MIDLAND
STEEL PRODUCTS CO.


Need Materials for
1. Oil Seal
2. Oil Wick
3. Stop Vibration
4. Absorb Sound

# MB mounts restrain "canned" jet engines




JET engines can experience vibration and shock problems before ever seeing service. It happens during transportation and handling, when they're in their shipping cans.

So special MB shock mounts are used to help protect P&WA J-57 engines in their containers. These units satisfy two important yet different performance requirements. They'll safely restrain the displacement and maximum "g" of the engine should the container be dropped even 3 feet. At the same time, they provide the cushioned mass with a natural frequency different from frequencies encountered in transportation, thereby avoiding resonance and consequent build-up of vibratory amplitudes.

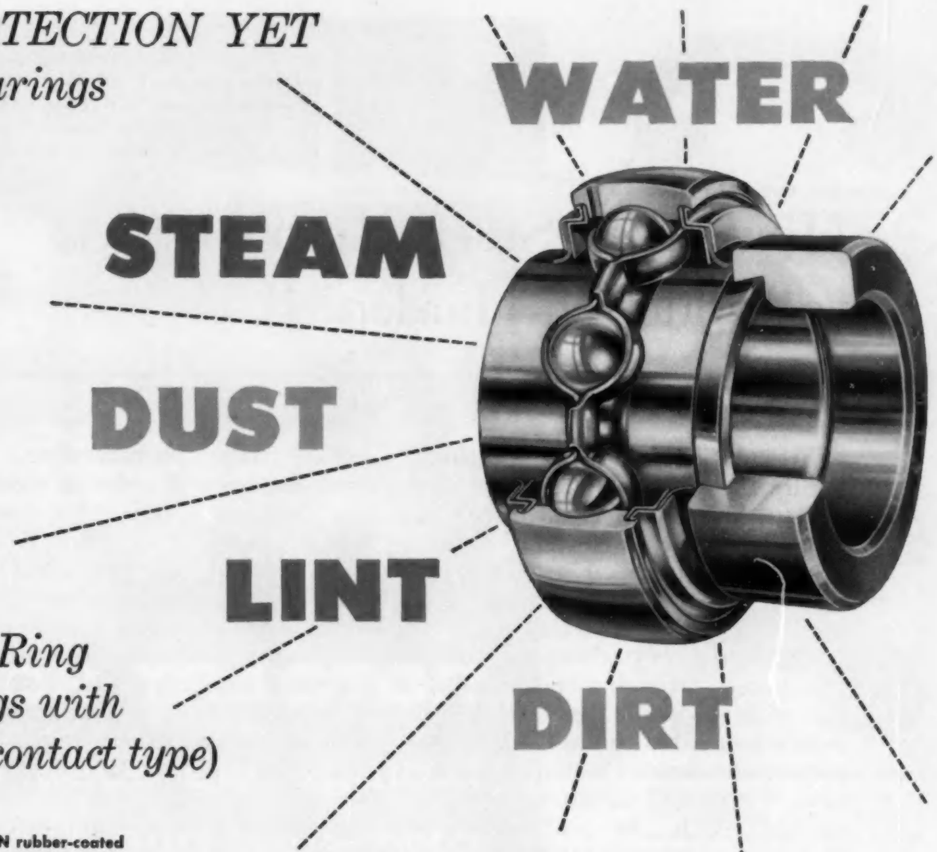
MB concentrates on mounts which start where ordinary units have to give up. Various mounts have been developed which, while available as *standard* units, are actually in the *special performance* class. Perhaps we can work out a modification of one to solve *your* particular vibration problem. Send for Bulletin 616A.

*manufacturing company* 1067 State Street New Haven 11, Conn.

*A Division of Textron Inc.*

HEADQUARTERS FOR PRODUCTS TO ISOLATE VIBRATION ... TO EXCITE IT ... TO MEASURE IT.

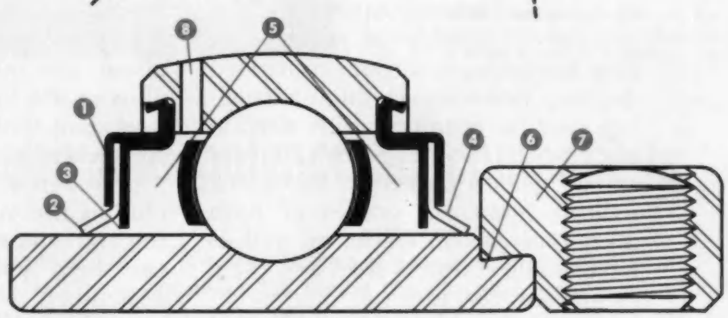
# *BEST PROTECTION YET for Ball Bearings exposed to*




## *FAFNIR Wide Inner Ring Ball Bearings with Plya-Seals (contact type)*

**FEATURES**

1. Plya-Seal of resilient Buna N rubber-coated fabric insuring proper "follow-up" contact
2. Seal rides in firm contact on ground outside diameter of inner ring
3. Close-clearance of inside metal shield with outside diameter of inner ring provides rigid support for seal
4. Flared lip of Plya-Seal won't push in
5. Generous space for lubricant
6. Wide inner ring for extra shaft support
7. Fafnir-originated self-locking, eccentric-cam-design collar
8. Relubricatable




On slow to moderate speed applications where service conditions are subject to excessive contamination, Fafnir Plya-Seal equipped Wide Inner Ring Ball Bearings fill a definite need. Their laboratory and field-tested performance offers the proven protection of contact-type Plya-Seals. They provide every advantage of Fafnir Wide Inner Ring Ball Bearings with Self-Locking Collars . . . ease of application, positive locking, extra large support area on the shaft, relubricatable or nonrelubricatable, self-alignments.

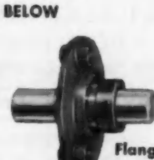
The Plya-Seal as incorporated in the Fafnir Wide Inner Ring Bearing consists of two steel plates between which is sandwiched a synthetic rubber-coated fabric sealing washer. Both steel plates are fixed securely in an outer ring groove. The inner plate provides a rigid backing for the seal and a close-clearance baffle for the retention of grease.

This recent addition to the Fafnir Line is dimensionally interchangeable with the Fafnir Wide Inner Ring Ball Bearings equipped with Mechani-Seals. All types are prelubricated at the factory. Write for descriptive bulletin. The Fafnir Bearing Company, New Britain, Connecticut.

**FAFNIR WIDE INNER RING BALL BEARING WITH PLYA-SEALS AVAILABLE IN UNITS BELOW**

RAK

RCJ



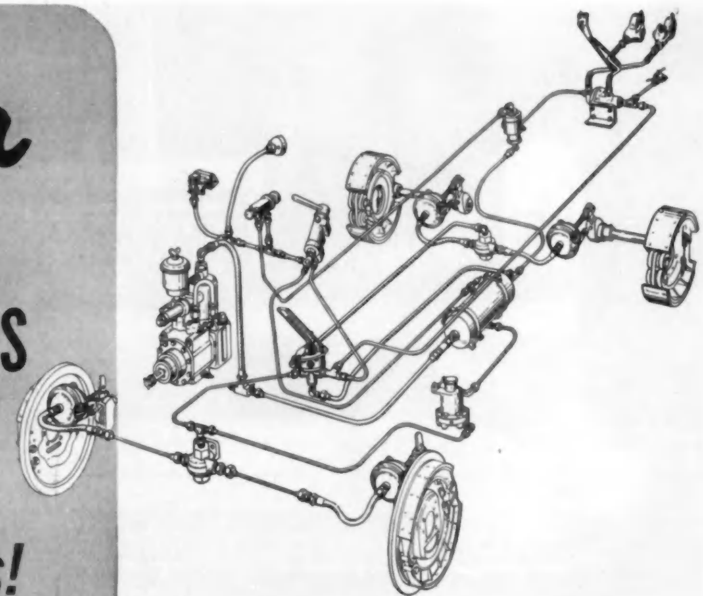
Flangette

**FAFNIR**
**BALL BEARINGS**
MOST COMPLETE LINE IN AMERICA

# Wagner

## STRAIGHT AIR BRAKE SYSTEMS

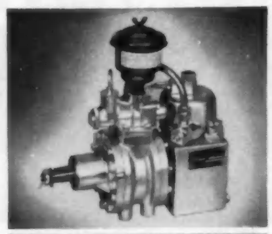
*provide safe, sure stops for cam type brakes!*

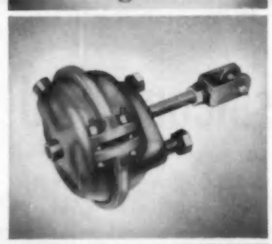


Wagner Straight-Air Brake actuating systems give cam type foundation brakes the ability to make quick, safe stops—completely controlled by the driver. They are furnished plenty of air at all times by the Wagner Rotary Air Compressor. The actuating units and application valves are *positive* in operation—performance-proved on many thousands of installations.

Wagner Air Brakes are the product of more than thirty years of brake engineering experience—gained in the designing and building of brake systems and brake parts for the automotive industry. When you equip the heavy-duty vehicles you manufacture with Wagner Air Brakes, you are adding safety and low-maintenance features that build customer acceptance.

Get all the facts on the Rotary Compressor and other features that make Wagner Straight-Air Systems so dependable and so safe. Write for your free copy of Catalog KU-201—it gives all the facts you should know about Wagner Air Brake Systems.





***features include:***

**WAGNER ROTARY AIR COMPRESSOR**—provides an abundance of air at all times. Its cool operation prevents carbon formation in air lines. Uniform torque load and smooth operation with moderate stresses assure long compressor life and long belt life.

**WAGNER BRAKE CHAMBERS**—have diaphragms of neoprene rubber bonded to high-tensile-strength *nylon* fabric for superior oil resistance and maximum strength and flexibility. Available with or without push-rod seal. All brake chamber parts are of corrosion-resistant material, or are plated to prevent rusting. Wagner Brake Chambers are interchangeable with all clamp type and bolt type units equipped with standard mounting studs, regardless of make.

**WAGNER MOISTURE EJECTION VALVE**—automatically keeps air reservoirs clean and dry by ejecting accumulated moisture with each average brake application—without causing a noticeable drop in tank pressure.

K57-11

**Wagner Electric Corporation**
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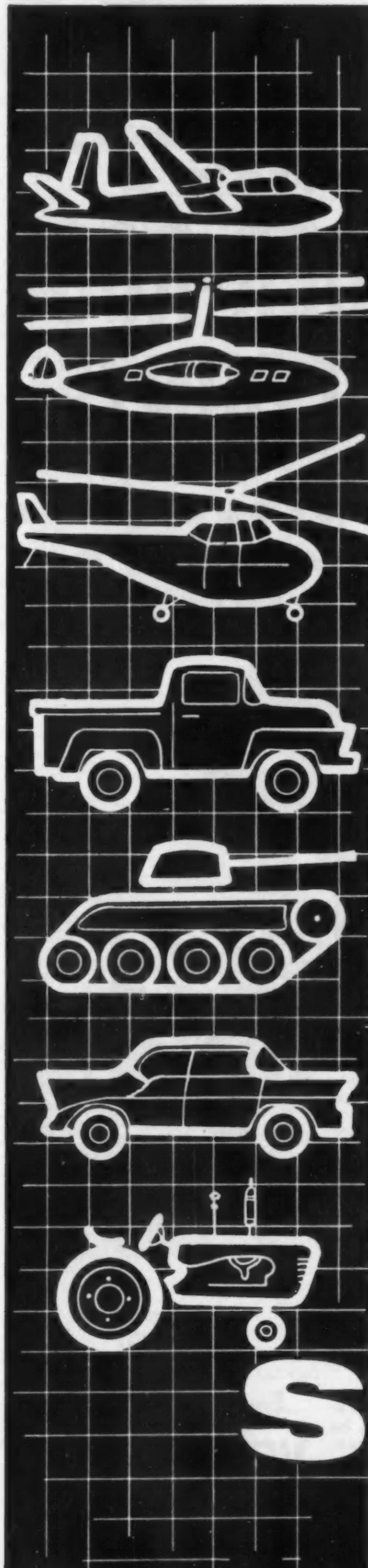
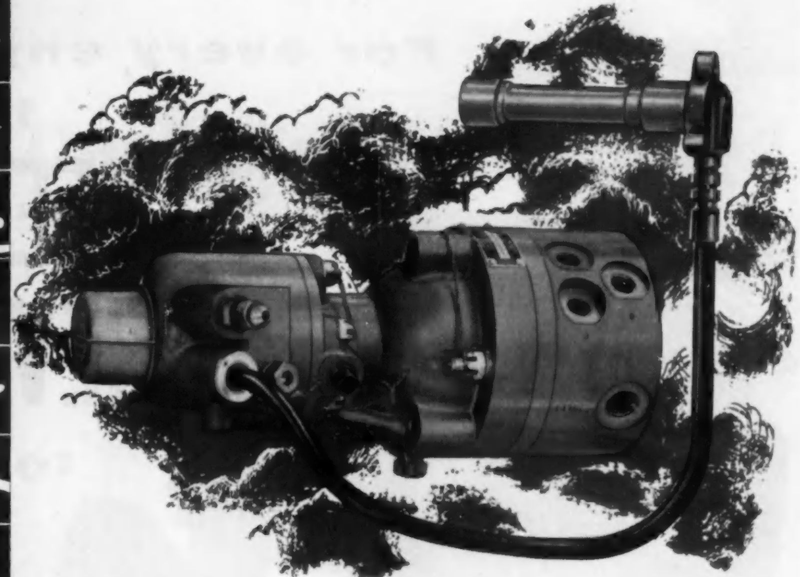
(Branches in principal cities in U. S. and in Canada)

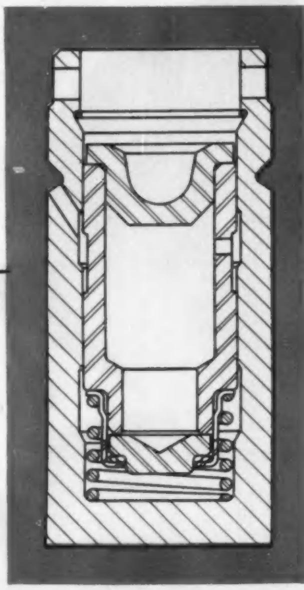
LOCKHEED HYDRAULIC BRAKE PARTS and FLUID • NoRoL • CoMaX BRAKE LINING • AIR BRAKES • AIR HORNS • TACHOGRAPHS • ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES



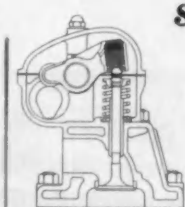


# Designing valve gear?

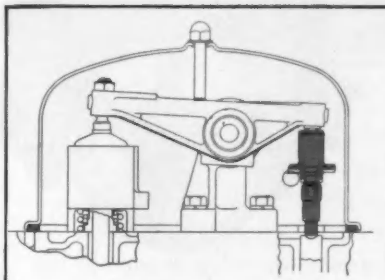
## *We invite you to use these specialized CHICAGO services*



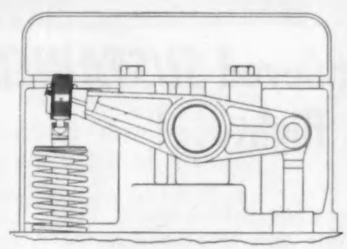
CHICAGO SPRING-LOADED FLAT VALVE HYDRAULIC TAPPET



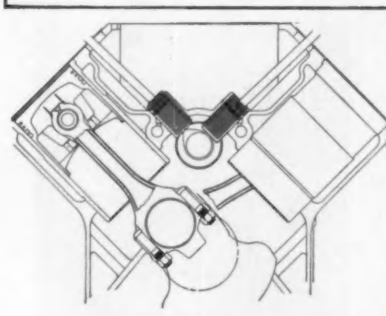
INSERT TYPE ROCKER ARM UNIT



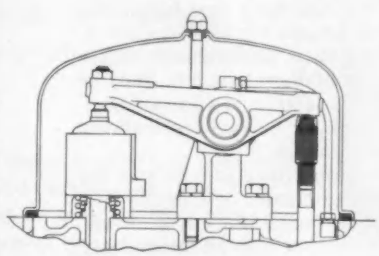
PUSH ROD TYPE FOR COMPRESSION RELEASE APPLICATION



THREADED TYPE ROCKER ARM UNIT



V-8 AUTOMOTIVE HYDRAULIC TAPPET APPLICATION



HYDRAULIC UNIT ON END OF PUSH ROD

### *Design*

of complete valve gear installations for any type of engine . . . passenger car, truck, tractor, diesel, aircraft or industrial.

### *Development engineering*

based on years of specialized experience in valve gear problems. The skills of our engineers will prove a valuable addition to your own engineering staff.

### *Tappet manufacturing*

CHICAGO's facilities insure precision-manufacturing, scientific testing and rugged, trouble-free performance in every tappet. We will welcome the opportunity to serve you.

**THE CHICAGO SCREW COMPANY**

DIVISION OF STANDARD SCREW COMPANY • ESTABLISHED 1872

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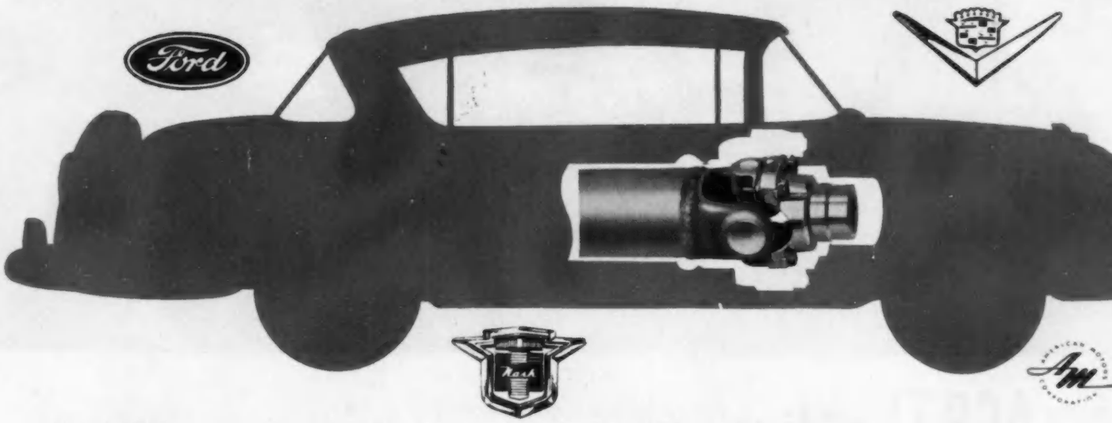
# FIRST



**FIRST** to make an Automobile Joint smaller —(3-9/16" swing diameter) to reduce the clearance needed by the low floor boards in modern cars.

**FIRST** to make the smaller joints stronger —(2500 lbs. ft. torque) to meet the needs of higher speed, higher power modern cars.

**FIRST** to make the smaller, stronger joints lighter—(20% less than other joints having the same torque capacity) to help designers keep overall weight down to modern standards.

**FIRST** to make the smaller, stronger, lighter joints easier to install—(less parts to handle) to save time and money on the assembly line.

Send a print and specifications of your new model for MECHANICS engineers' recommendations how you can give your next car the benefit of these four competitive advantages—provided by the new MECHANICS joint development.

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# MILESTONES IN POWER PROGRESS

(NO. 4 IN A SERIES)

*1912 — First electric starter*

## *1952 — First thin-wall plastic case was introduced by GLOBE*

The first electric starter made good batteries absolutely essential to trouble-free motoring. And Globe-Union — already pioneering in the field — has kept right on working through the years to make those good batteries even better. A typical Globe improvement "first" is the thin-wall plastic battery case—perfected in 1952 after 10 years of research to provide—

*21% more acid capacity*
*96% increase in resistance to impact*
*40% greater resistance to acid penetration*

Impact test

Bulge test

The battery that's built to take brute punishment and *give* peak performance for tens of thousands of hard-driving miles. Proof of strength is thin-wall container's score on the "Impact test and Bulge test" as illustrated above. Proof of container's extra acid capacity is shown in side-by-side comparison of thin-wall plastic design with composition material design . . . use of new plastics also means less acid absorption without contamination of acid.

Another milestone in power — another first for Globe!

### *FASTER, LOW-COST DELIVERY!*

Globe's sixteen plants are strategically located for fastest, lowest-cost shipments to all markets; fourteen (*) are producing creatively packaged dry-charged batteries.

*ATLANTA, GA., *DALLAS, TEXAS, *EMPORIA, KANSAS, *HOUSTON, TEXAS, *LOUISVILLE, KY., *MEDFORD, MASS., *MEMPHIS, TENN., *MILWAUKEE, WIS., *MINERAL RIDGE, OHIO, *PHILADELPHIA, PA., *REIDSVILLE, NO. CAROLINA, *SAN JOSE, CALIF., *HASTINGS-ON-HUDSON, N. Y., *LOS ANGELES, CALIF., OREGON CITY, ORE., AJAX (ONTARIO) CANADA

SPINNING POWER
GLOBE-UNION
SPLIT-SECOND STARTING

# GLOBE-UNION INC.

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***If it's Petroleum-powered there's a GLOBE-BUILT BATTERY right from the start!***

# LONG OIL COOLERS CAN HELP SELL YOUR PRODUCTS

**For top efficiency from heavy-duty powered equipment, the oil in engines, transmissions, torque converters and hydraulic units must be protected from heat. As their operating requirements are stepped up, this problem becomes more acute.**

GIVE your customers the benefits of *Long* thermally and mechanically efficient oil coolers, built by this 53-year leader in heat exchangers. *Long* engineers' design ingenuity in combining standard elements enables us to produce a wide variety of sizes, capacities and shapes without high tooling costs.

- Available in wafer, multiple plate, shell and tube, fin and tube, and manifold types
- For single or multi-pass, oil to water and oil to air cooling
- Applicable to automotive, industrial, marine, hydraulic and other mobile or stationary powered units
- Designed for installation in radiator tank, engine block or as an accessory
- Quality and performance tested and proved in *Long* laboratory

Write for engineering data sheets and information forms to obtain application recommendations. If you need immediate help, ask to have a representative call on you.

**TORQUE CONVERTERS**
**CLUTCHES**
**HEAT EXCHANGERS**

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**THE STANDARD OF QUALITY AND PERFORMANCE SINCE 1903**

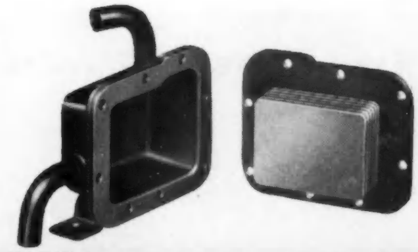
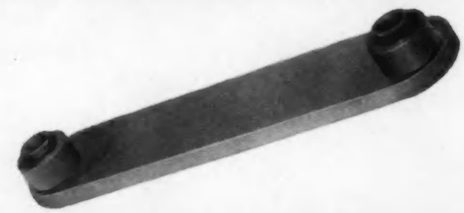
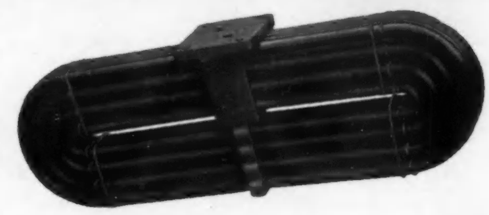


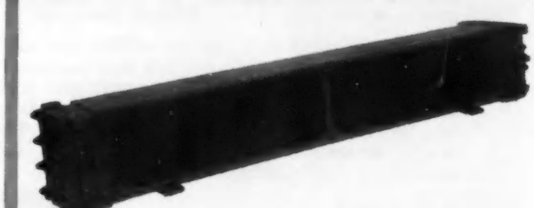
Plate type oil cooler is highly flexible and efficient for engine installation or for torque converters, transmissions or hydraulic presses.



Wafer type, submerged in lower radiator tank, cools transmission oil in automobiles.

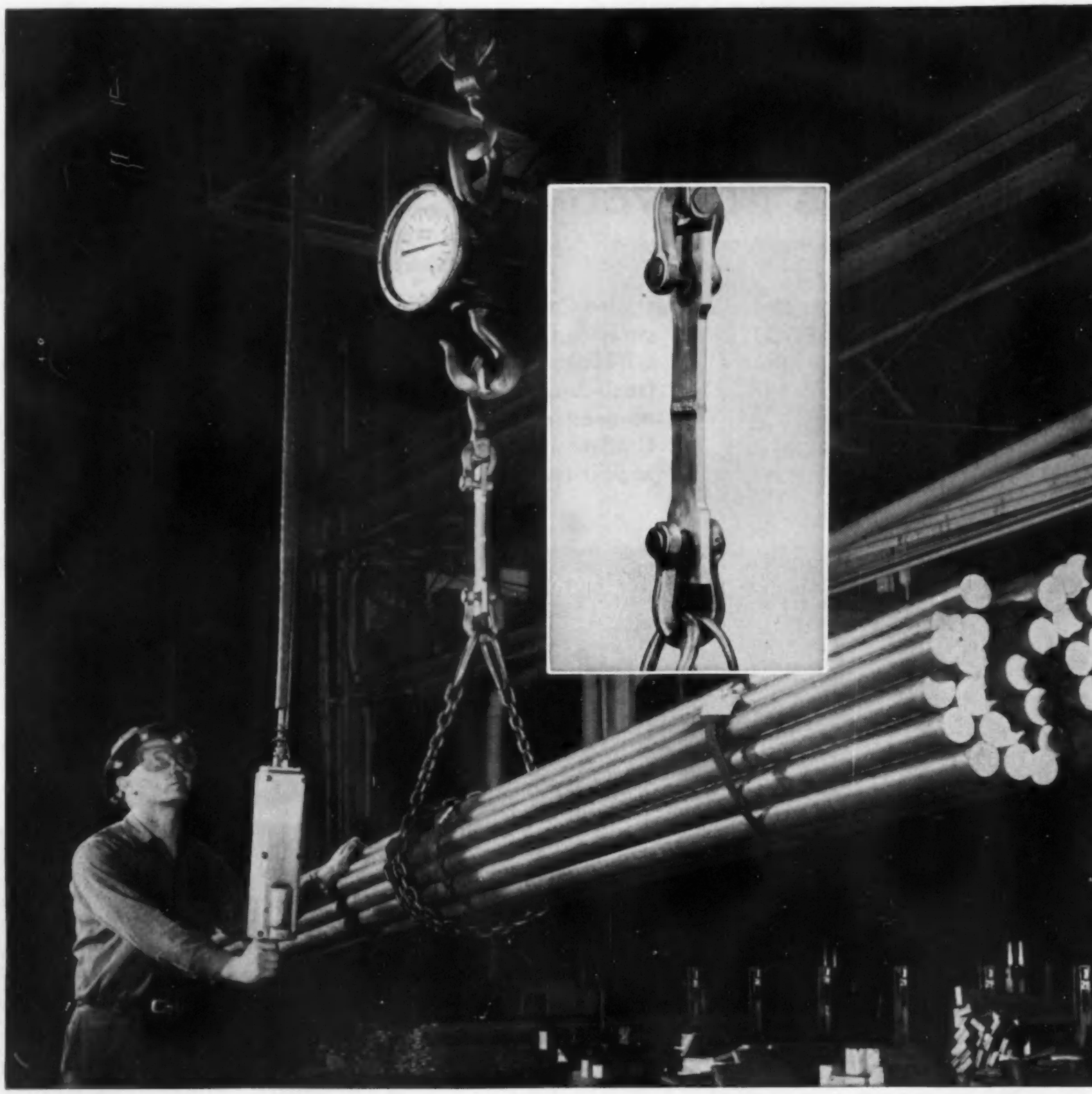


Large capacity of manifold type, fabricated from seamless copper tubing, makes it suitable for heavy-duty engines.



Fin and tube unit can be used for liquid to air cooling wherever a fan can be installed behind it. Suitable for vehicles, factories, trains and power plants.

Shell and tube liquid to liquid heat exchanger is applicable to vehicles and industrial purposes and as process cooler in manufacturing fluid products.




DANA PRODUCTS put POWER
DANA PRODUCTS Serve Many Fields:
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MARINE: Universal Joints, Propeller Shafts, Gear Boxes.
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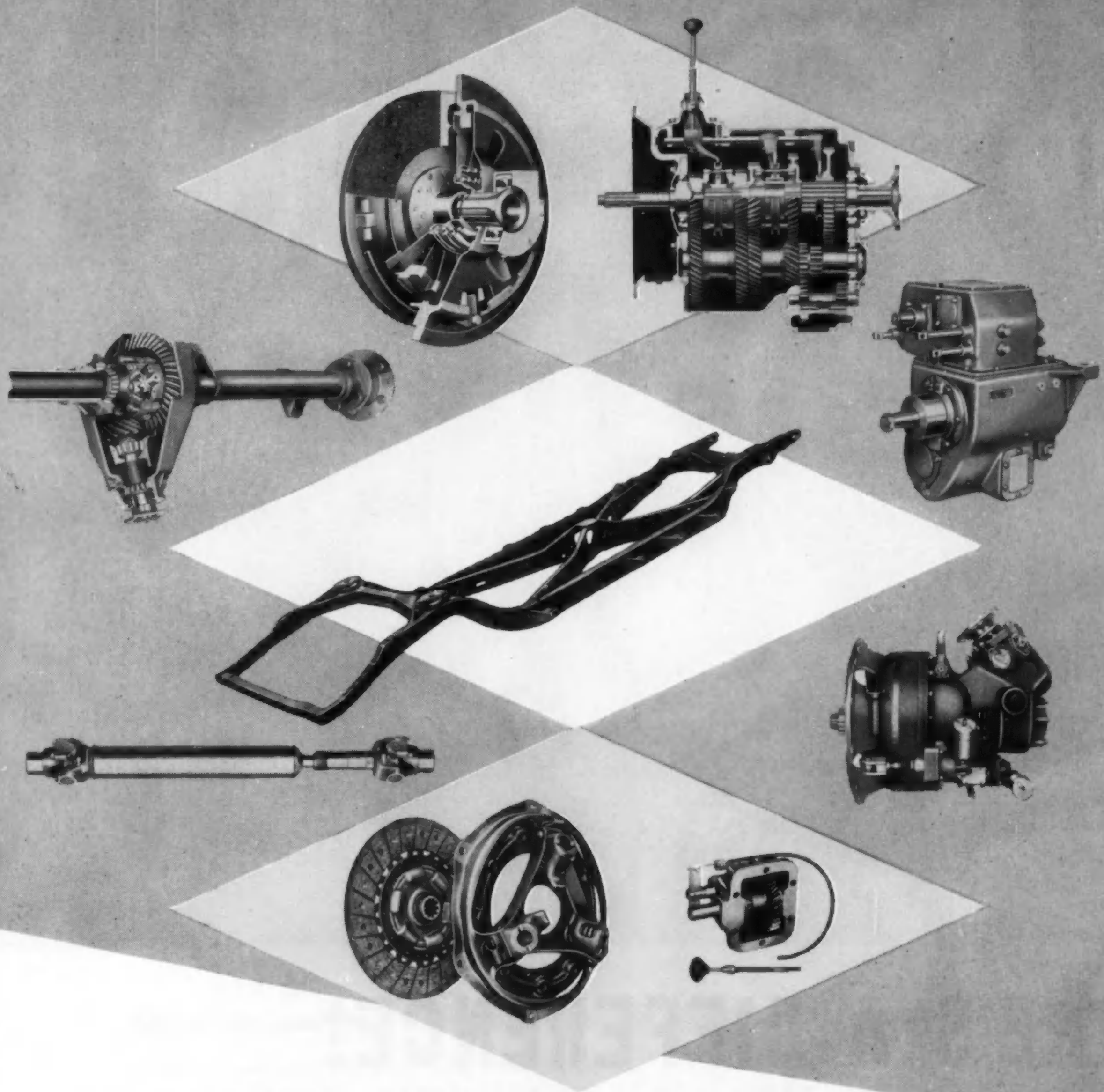
Many of these products manufactured in Canada by Hayes Steel Products Limited, Merritton, Ontario
DANA CORPORATION




# THERE'S A DIFFERENCE!

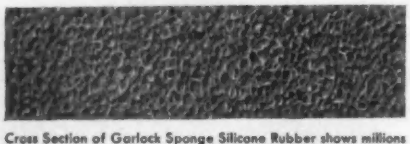
## (One is Garlock's New Sponge Silicone Rubber for temperatures from $-100°F$ to $+500°F$)

The hand on the right holds Garlock's latest development . . . Sponge Silicone Rubber. The other hand holds "ordinary" sponge rubber. Outwardly, they look the same, the difference is that Sponge Silicone will remain flexible at temperature extremes, sheds water, resists adhesion of ice, resists tearing or abrasion . . . in fact, Garlock Sponge Silicone Rubber is the ideal seal for around airframe openings like doors, ports, bomb bays or hoods.

Millions of non-connecting cells provide Sponge Silicone Rubber with a natural insulation which, together with the base material, make it able to withstand temperatures from $-100°F$ to $+500°F$ . . . and still remain flexible. Moreover, Garlock Sponge Silicone Rubber can be extruded, thick or thin, in a variety of forms with very low compression set. It's available in sheets, round and odd extruded cross sections, or simple extruded cross sections for splicing into endless rings.

New, soft Sponge Silicone is the latest of the "Garlock 2000" . . . two thousand different styles of packings, gaskets, and seals for every need. It's the only complete line. That's why you get unbiased recommendations from your Garlock representative. Call him today!

CROSS SECTION



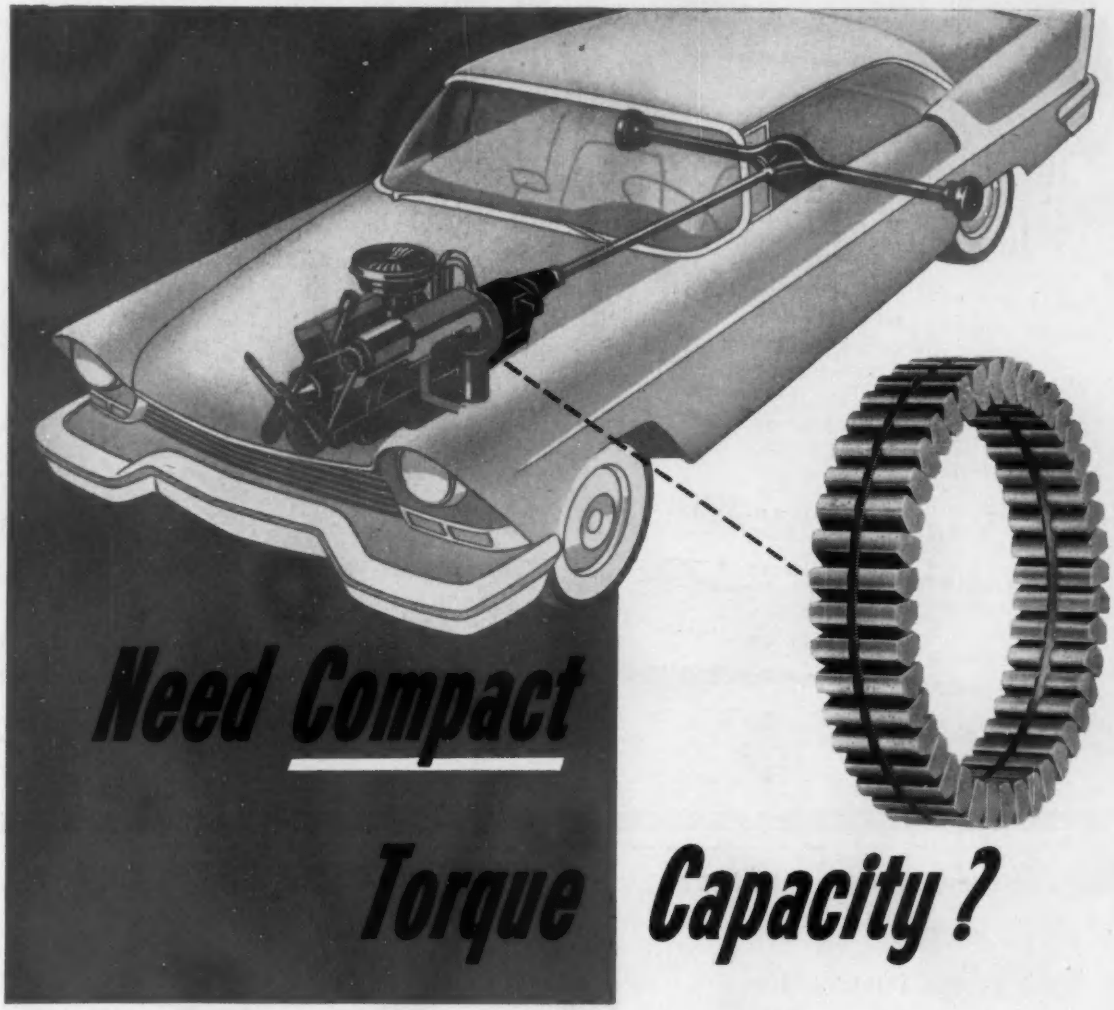
Cross Section of Garlock Sponge Silicone Rubber shows millions of non-connecting cells which provide natural insulation as well as low temperature flexibility to $-100°$ F. . . . heat resistance to $+500°$ F.

**THE GARLOCK PACKING COMPANY, Palmyra, N. Y.**

**For Prompt Service,** contact one of our 30 sales offices and warehouses throughout the U. S. and Canada.

GARLOCK

*Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints, Fluorocarbon Products*




## Formsprag Full-Complement Over-running Clutches eliminate artificial spacing and built-in drag

In automotive, aircraft, truck and farm implement power transmission applications—designers are exceedingly aware of the need for increased torque capacity in less space.

Formsprag Clutches provide a positive solution. The backbone of these over-running clutches is the exclusive, highly-developed sprag. Due to their construction, a full-complement of sprags can be fitted into a given space . . . *and they space automatically*. The result: Greater engine torque capacity is transmitted and the unit is compact.

In addition, no built-in drag is required. The consequent wear is eliminated and you are guaranteed of much longer clutch life.

As the pioneer in the manufacture of sprag clutches, Formsprag offers the finest in precision manufacture and design facilities. Simple, basic design makes them ideal for economical prototypes for testing. *Complete* clutches are a specialty.

"Need Compact Torque Capacity?" Call on Formsprag—World's largest exclusive manufacturer of over-running clutches.

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*THE ONLY CLUTCH THAT CAN GIVE YOU FULL-COMPLEMENT PERFORMANCE*

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# GENERAL RADIATOR

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and specialized engineering experience. We work from your specs, give competitive quotes, or start from scratch to design *with you* the *right* heat transfer equipment for your mobile or stationary engines of any kind.

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- **Is an attractive gold-filled clutch-back pin**
- **Costs only $1.50** plus 15¢ Federal tax for delivery in the United States and 5¢ sales tax for delivery in New York City

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Please send me an SAE emblem. Enclosed is my check for $...... ($1.50 plus applicable taxes). Grade of membership (please check)

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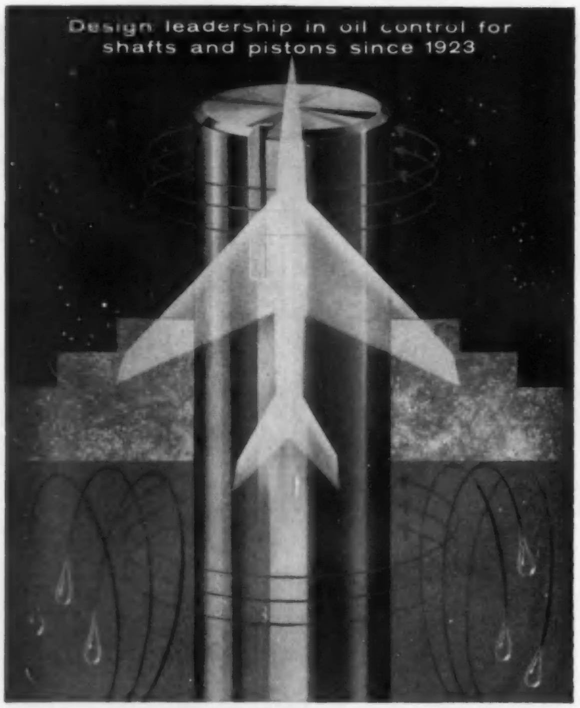


# HIGH SPEED shaft sealing problems?

## ...solve them with SIMPLEX

Shaft speeds to 20,000 rpm and higher present special problems in shaft seal design — especially when high temperatures or other special conditions may also be involved.

To designers and builders of jet or reciprocating engines and auxiliaries, SIMPLEX offers exclusive design principles and extended industry experience in solving similar problems. SIMPLEX products are original equipment in Allison, Pratt & Whitney, Wright and other leading aircraft engines.

Whether your oil control problems involve shaft seals or piston rings, SIMPLEX engineers will be glad to help you work them out. Call, wire or write.

**Simplex Piston Ring Mfg. Co.**

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75 N. E. 74th STREET • MIAMI 38, FLORIDA

**SIMPLEX**
HIGH SPEED SHAFT SEALS AND PISTON RINGS

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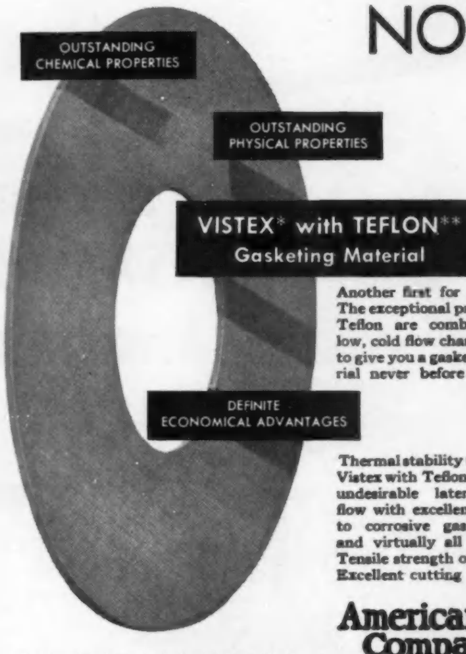


Another first for American! The exceptional properties of Teflon are combined with low, cold flow characteristics to give you a gasketing material never before available.

Thermal stability up to 420F. Vistex with Teflon eliminates undesirable lateral plastic flow with excellent stability to corrosive gases, liquids and virtually all chemicals. Tensile strength of 5,000 psi. Excellent cutting properties.

*VISTEX—Reg. Trade-mark of American Felt Company
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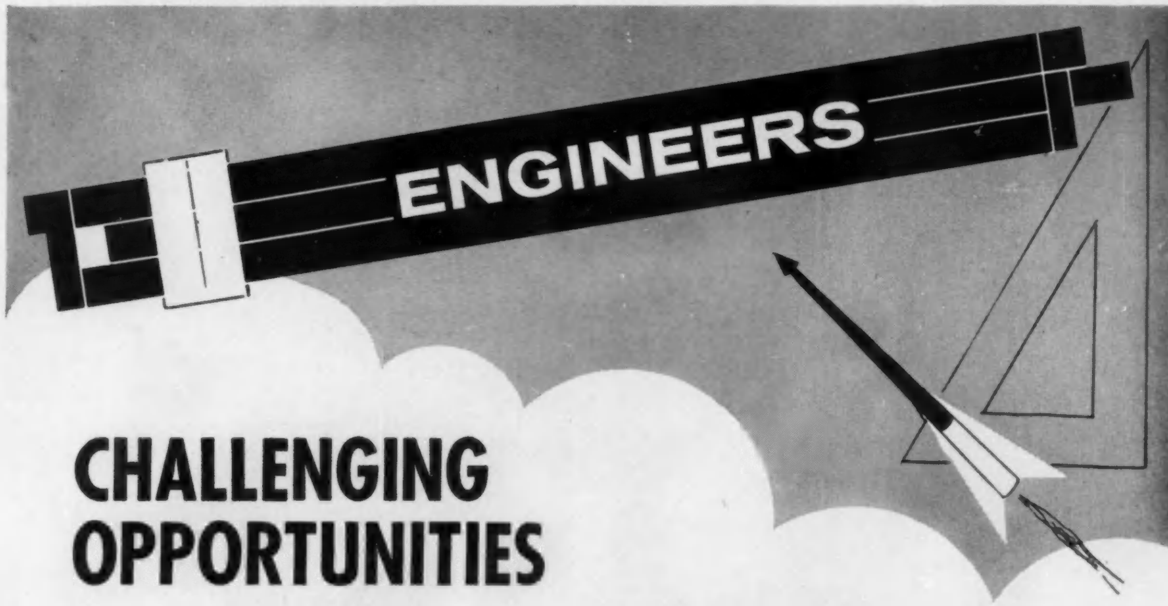


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## General Motors

ALL GRADUATE ENGINEERS are offered permanent job opportunities. We extend a cordial invitation to every deserving Engineer and Designer to write us their wants. We may be able to supply the square hole for the square peg!

YOUR FUTURE depends on your making the right connection with the right firm as quickly as possible.

The men hired will enjoy working with some of the top men in the field and with the finest test, research and development facilities. GM's long-standing policy of decentralization creates individual opportunity and recognition.

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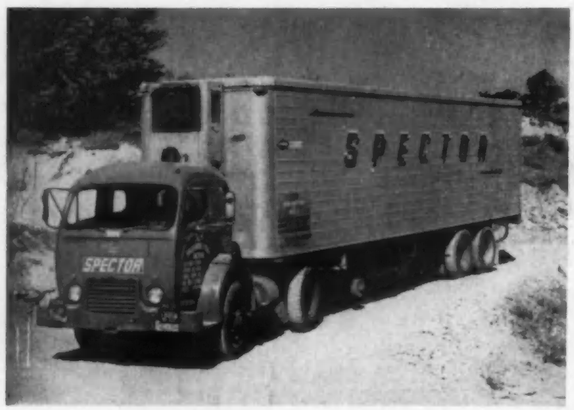
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